WCMC Biodiversity Series No 5

Assessing Biodiversity

Status and Sustainability

WORLD CONSERVATION
MONITORING CENTRE

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by the

World Conservation Monitoring Centre

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Editors

B Groombridge and M D Jenkins

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This document

This report was originally prepared by the World Conservation Monitoring Centre (WCMC) under contract to the Overseas Development Administration (ODA), UK. The work began in 1994 and the final draft was submitted in August 1995. The task assigned to WCMC was to propose approaches and methods for use by developing country governments to assess the status of national biodiversity and the sustainability of current and projected uses. The document is now made available in the present format by kind permission of the ODA (this version differs from the original in a few minor improvements to the text; no new research has been undertaken).

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EXECUTIVE SUMMARY

The aim of this document is to outline approaches suitable for use by developing countries to assess, with reference to socio-economic factors, the status and sustainability of national biodiversity.

Because biodiversity is such an all-encompassing concept, it is vital that questions asked of it are properly focused, with particular reference to context and spatial scale. At the national level, each country has a unique endowment of species and habitats which may be used sustainably as the country sees fit, but each country also contributes to global biodiversity and has a responsibility to play a part in its maintenance.

Despite recent emphasis on the property of sustainability, there are few studies on how in practice to measure this: the concept may refer to use of a specific resource (fishes, timber), or to the ideal of sustainable human development. Recent discussion has elaborated the concept of ecosystem health and the need to maintain this, defined in terms of key structures and processes, as an over-arching goal. However, ecosystem health remains difficult to measure in practice. In light of this, the current best option is to revert to the goal of maintaining the elements of ecosystems (populations, species, habitats) and to adopt the precautionary principle so that the widest possible range of species and habitats, and the largest possible area of ecosystems are maintained.

Different aspects of biological resource use will be of particular interest at different scales and in countries at different stages of economic development: although there is no single methodology that can be applied to all situations, a conceptual framework can be developed and general guidelines proposed. In particular it will be necessary for each country to establish the appropriate balance between demands to conserve every element of biodiversity, or to conserve only those elements demonstrably essential to human well-being; the key problem is that the costs and the benefits entailed by each such trade-off will have different impacts at different spatial scales and among different sectors of society.

To help ensure a wide spectrum of biodiversity is maintained, two different but complementary approaches are needed: one concerned with maintaining the option and existence (intangible) benefits derived from biodiversity, the other focused on the direct use values.

Intangible benefits are best maintained by ensuring that ecosystems remain as healthy as possible, and persist in sufficient area: an efficient protected areas system is the best response to this need.

Direct use benefits can only be maintained by focusing on the resources in question; at the macroeconomic level marine fisheries and timber are by far the most significant sectors of use: not only are the products of great importance to humans but they are derived largely from wild resources. Assessment of the impact of harvest of these and other wild resources is problematic. It is becoming increasingly evident that effective management of these resources requires an approach based on ecosystem functioning.

All management of wild resources requires baseline information concerning both status of the resources and the human activities which impinge on them.

Data requirements on the status of wild resource should be selected and prioritised according to national strategic goals and the UNEP Country Study Guidelines. A large number of techniques have been developed for rapid biodiversity assessment, several based on extrapolation from occurrence of indicator groups.

As a first step, sources of existing data should be identified; research should then be undertaken to fill gaps in information. The aim is to set baselines in order to monitor and identify trends. Emphasis should be placed on endemic species, threatened species and resource species; information gathered should include importance to human communities, rates of use and of loss. Priority geographic areas are those rich in such species, and areas where human use of them is critical.

Assessment of habitat change at global level is hindered by lack of a standard habitat classification; assessment at national level and below requires at minimum an internally consistent scheme that need not necessarily apply elsewhere.

The status of individual species is best assessed using the revised IUCN/SSC category system which is being enhanced to apply at national as well as global level; evaluating genetic erosion is of particular importance for biological resources, including domestic species, local varieties, and their wild relatives, but is technically demanding.

Assessment of the status of biodiversity should proceed hand-in-hand with assessment of the socio-economic factors determining biodiversity use. For these studies it is essential to determine the appropriate spatial scales for study: for many purposes the local village level will often be most important. However regional and national level analysis is also important for a complete understanding of the exploitation of major resources, such as fisheries and timber. Realistic goals must be adopted. This will entail combining secondary material with select in-depth analyses and numerous rapid surveys to reduce ignorance to a level where appropriate action is possible.

Varieties of Rural Rapid Appraisal (RRA) can provide an overview of those socio-economic sectors most dependent on direct use of biological resources in subsistence and mixed economies at the village level, but should be combined with selected in-depth studies. Economic analysis is more difficult in market economies because complex modelling is needed and input data are scarce.

Analysis at all spatial scales of the socio-economic factors affecting use of biodiversity will provide insight into the underlying or ultimate threats to biodiversity. Major factors are: land tenure and access rights; population growth; inequitable distribution of the costs and benefits of biodiversity conservation; distortions in the economy, caused by government policies and misleading market prices.

Addressing these problems is a major challenge. Long-term stable funding of conservation efforts is required to meet recurrent costs and to ensure long-term goals are met. The great majority of Less Developed Countries are not at present in a position to meet these costs without external financial and technical assistance.

1. INTRODUCTION

Summary

- *the aim of this document is to outline approaches suitable for use by developing countries to assess, with reference to socio-economic factors, the status and sustainability of national biodiversity;*

- *each country has a unique endowment of species and habitats which may be used sustainably as the country sees fit, but each country also contributes to global biodiversity and has a responsibility to play a part in its maintenance;*

- *because biodiversity is such an all-encompassing concept, it is vital that questions asked of it are properly focused, with particular reference to context and spatial scale;*

- *despite recent emphasis on the property of sustainability, there are few studies on how in practice to measure this: the concept may refer to use of a specific resource (fishes, timber), or to the ideal of sustainable human development;*

- *recent discussion has elaborated the concept of ecosystem health and the need to maintain this, defined in terms of key structures and processes, as an over-arching goal: ecosystem health remains difficult to measure in practice;*

- *the current best option is to revert to the goal of maintaining the elements of ecosystems (populations, species, habitats) and to adopt the precautionary principle so that the widest possible range of species and habitats, and the largest possible area of ecosystems, are maintained;*

- *it will be necessary for each country to establish the appropriate balance between demands to conserve every element of biodiversity, or to conserve only those elements demonstrably essential to human well-being; the key problem is that the costs and the benefits entailed by each such trade-off will have different impacts at different spatial scales and among different sectors of society;*

- *different aspects of biological resource use will be of particular interest at different scales and in countries at different stages of economic development: although there is no single methodology that can be applied to all situations, a conceptual framework can be developed and general guidelines proposed.*

1.1 PURPOSE OF THIS DOCUMENT

1.1.2 The intention of this document is to propose approaches and methods suitable for use by developing country governments to assess the status of national biodiversity and the sustainability of current and projected biodiversity uses.

1.1.3 The need for these kinds of assessment is made explicit in the text of the Convention on Biological Diversity (CBD) (UNEP, 1992). The CBD opened for signature in June 1992 at the United Nations Conference on Environment and Development, and entered into force on 29 December 1993. The objectives of the Convention are threefold (paraphrased from Article 1 of the CBD text):

- the conservation of biological diversity,
- the sustainable use of its components, and
- the equitable sharing of benefits from use of genetic resources.

1.1.4 In effect, the CBD aims to encourage and enable all countries to conserve biological diversity, to ensure that its use in support of national development is sustainable, and to reconcile national interests with the maintenance of highest possible levels of global biodiversity. Each country has its own unique combination of living species, habitats and ecosystems which together make up its biodiversity resource. Implicit in the CBD is the concept that each country may exploit sustainably its own biodiversity in any way which it sees fit, and because each country also contributes to overall global biodiversity, it has a corresponding responsibility to play a part in its maintenance.

1.1.5 To enable it to carry out these functions effectively, each country requires a sound baseline understanding of its own biodiversity, and how it fits into the global pattern, followed by assessments of change in the status of biodiversity over time, and of the sustainability of human uses of biodiversity. Finally, the policy, institutional and social framework must be capable of making responses appropriate to such assessments.

1.1.6 This document is concerned with biodiversity assessment: more general issues in biodiversity data management are addressed elsewhere. The UNEP/WCMC Biodiversity Data Management project (supported by the Global Environment Facility) is designed to facilitate the building of national capacity for biodiversity data management and exchange under the CBD. Materials from this project are now becoming available: *Guidelines for National Institutional Survey* (a framework for recording institutional involvement in biodiversity data management), *Framework for Information Management* (principles and techniques for developing national information systems to produce policy-relevant information for decision making) (UNEP/WCMC, 1996), and *The Resource Inventory* (tools, data exchange standards, thematic information standards, sources, reference material) (UNEP/WCMC, 1995).

1.1.7 Because biodiversity is such an all-encompassing concept, it is vital that questions relating to it are focused. It is important to emphasise, for example, the distinction between ecological services such as the role of forest cover in the prevention of erosion, where diversity is not the paramount issue, and the role of land races in maintaining crop yields under varying conditions, where biological diversity in the strict sense is the major factor.

1.1.8 Conservation activities, often funded by international and bilateral agencies, are in progress in most countries at present. Major problems with them tend to be: lack of coordination, leading to duplication and dissipation of effort; difficulty in translating knowledge into action; and lack of political will to carry out actions. It is emphasised in this document that a major priority in all countries is therefore to make more efficient use of existing resources, activities and institutions. A first step should always be to determine whether required information already exists in government archives or in academic or NGO reports, and needs only to be located rather than researched anew. Note, however, that many standard sets of statistical data will exclude subsistence economies and underestimate rural production, immigration, and other parameters.

1.1.9 Investigation of the sustainability of biodiversity use requires evaluation of biological data in the context of human social, economic, and cultural development. These socio-economic factors are paramount in establishing a balance between the conservation, preservation, and extensive exploitation of biodiversity resources. The needs, concerns, and priorities of local communities, and regional and national administrations with regard to biodiversity may be different and even conflicting. All three groups play a significant role in maintaining or depleting biodiversity. Therefore, where possible, the socio-economic issues should be considered at the local, regional and national level.

1.1.10 Despite the implementation of many Integrated Conservation and Development Projects (ICDPs) it remains in practice difficult to connect the goals of workers focusing primarily on biodiversity conservation and those concerned mainly with human well-being, and to achieve sufficient consensus between local communities and other national sectors. Achieving such connections is complicated by, among other factors, questions of spatial and temporal scale.

1.1.11 While some problems of monitoring and assessment have technical solutions, there is also a challenging but fundamental requirement to address the sustainability of staff and institutions, particularly in terms of funding support, in order to make use of these techniques.

1.2 STRUCTURE OF THIS DOCUMENT

The introductory material in this chapter is intended to set the context for the study. It provides basic definitions of biodiversity and outlines the various ways in which it is used and valued by mankind. It then discusses the concept of sustainability and the difficulties involved in making this concept operational, drawing particular attention to questions of spatial and temporal scale. It then focuses on two different but complementary values of biodiversity which need to be addressed, *option values* and *direct use values*. Chapter 2 outlines a framework for dealing with these. Subsequent chapters deal with: (#3) inventory methods, (#4) investigation of users of biodiversity and the socio-economic importance of that use, (#5) methods to assess the socio-economic origin of major threats to biodiversity, and (#6) conclusions and implications for funding.

1.3 THE MEANING OF BIODIVERSITY

1.3.1 Biodiversity is a term which has gained enormous currency in the past few years. The more widely it is used, the less precisely it is defined and the less well it is understood. Technically, it is a contraction of 'biological diversity'. For the purposes of the CBD (Article 2. Use of Terms), 'biological diversity' is "*the variability among living organisms from all sources including*, inter alia, *terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems*". In practice, 'biodiversity' is most often used as a collective noun synonymous with nature or 'Life on Earth'.

1.3.2 It has become customary to address biological diversity at three hierarchical levels - genes, species and ecosystems. In practice, species diversity is central to the evaluation of diversity at other levels, and is a constant point of reference in biodiversity studies. However,

diversity or heterogeneity is evident at all levels of biological organisation - from molecules to ecosystems - and this diversity has different functional significance at each level. Different manifestations of biodiversity become of significance at different scales, and according to the practical or ethical interests of humans.

Biological diversity as a resource

1.3.3 In terms of human uses and needs, biodiversity can be looked on as part of the entire capital stock on which development is based. This stock can be divided into: *natural capital*, living and non-living environmental assets, including biodiversity; *fabricated capital*, machines, buildings, infrastructure; *human capital*, human resources, and *social capital*, the social framework (Serageldin and Steer, 1994). Analysing biodiversity within this context is an extremely complex task but one which lies at the heart of all discussions concerning its sustainable use. This complexity arises because of the multitude of different ways and range of different scales, both in time and space, in which any given resource can viewed.

1.3.4 A theoretical distinction can be drawn between the value of some element of biodiversity as a biological resource and the value of diversity itself. The latter is much more difficult to conceptualise and attach a value to than the former. For example, the estimation of maize production (ie. the value of maize as a biological resource) is straightforward, but the calculation of the marginal contribution of genetic diversity from maize varieties is much harder. Strictly speaking, an assessment of the importance of biodiversity *per se* and attempts to measure the sustainability of its use would focus upon the latter, ie. the value of diversity, but in practice it is virtually impossible to disentangle the two and it makes far more sense to consider the individual components of biodiversity, be they genes, populations, species or ecosystems, as biological resources to be assessed and managed.

1.3.5 A framework of 'total economic value' helps to clarify this. Any given resource may have several different forms of economic value attached to it. *Direct values* are derived from the goods and services that are used in consumption or production; *Indirect values* are functions of the resources, for example watershed protection of forests regulates water flow, maize varieties providing security from complete crop failure; *Option values* are associated with the future potential uses of biodiversity, such as a pharmaceutical discovery; *Existence values* are derived by an individual from the mere knowledge that biodiversity continues to exist. Direct use values tend to reflect the value of the biological resource; option and existence values tend to reflect the value of diversity; and indirect values tend to reflect a mix of both. A fifth value is also sometimes regarded as a part of total economic value. This is *Bequest value*, which is the value of leaving the other values (both use and non-use) to future generations.

1.3.6 Whether such an economic framework will ultimately prove the most fruitful way of examining the true value of biodiversity, particularly in the realms of existence and bequest values, where ethical and aesthetic considerations predominate, is perhaps debatable.

1.4 THE MEANING OF SUSTAINABILITY

1.4.1 Like biodiversity, sustainability is a term which has been increasingly widely used over the past few years. It too is used in many different contexts and has come to mean many different things. It is thus extremely difficult to attach a single meaning to the term, let alone assess it quantitatively.

1.4.2 The concept of sustainability is most widely used at present in two separate, though related, ways. The first is with reference to the sustainable use of a specific resource or suite of resources, as in sustainable production of timber. The second is a much more general notion of sustainable development.

Sustainable resource use

1.4.3 In the context of direct extractive natural resource use, 'sustainable' means most simply that an activity can be carried out within some band of intensity, through the foreseeable future. This is exemplified by the fisheries concept of sustainable yield derived from a target population. Sustainability will vary according to biological features of the resource and its ecological surroundings, and to levels of use and the effects of any socio-economic controls on that use.

1.4.4 More formally, and with a biological emphasis (IUCN, 1993), 'sustainable use' may be defined as: "*use that does not reduce the future use potential, or impair the long term viability, of either the species being used or other species; and is compatible with maintenance of the long term viability of supporting and dependent ecosystems*". The text of the Convention on Biological Diversity itself (Article 2. Use of Terms) defines 'sustainable use' as: "*the use of components of biological diversity in a way and at a rate that does not lead to the long-term decline of biological diversity, thereby maintaining its potential to meet the needs and aspirations of present and future generations.*"

1.4.5 These definitions go beyond the simple basic concept of sustainability, with reference to some given target stock, to include the requirement that other (non-target) species and ecosystems suffer no lasting damage.

Sustainable development

1.4.6 The goal of sustainable development is to meet current human needs, in particular of the world's poor and disadvantaged, while also ensuring that future human generations at the very least have the same opportunities for survival and for personal and cultural development as present generations. At this level the concept is particularly problematic. Rapport (1995) argues on the basis of thermodynamics that the notion of sustainable development is at best ambiguous and at worst a contradiction in terms. Three strong reasons for this are: a significant proportion of the world's population is living in poverty (ie. is perceived as not having its current needs met); the world's human population is still increasing at a very rapid rate; and much of the current energy consumption of the world's population is based on the conversion of non-renewable resources (fossil fuels). Given these, any notion of sustainable development measured in conventional economic terms does not appear a realistic concept.

1.4.7 Other definitions of sustainability have attempted to circumvent these problems. Thus the concept has also been defined in broad economic terms, such that this criterion is met if the entire capital stock (discussed above) on which development is based is maintained, although acknowledging that degrees of conversion between components of overall capital will be necessary (eg. converting some stocks of oil into means of sustainable energy production, or via education, into increased human capital) (Serageldin and Steer, 1994).

1.4.8 Even if these much broader notions of sustainability are accepted, the continued expansion of global human population and the very unequal distribution of benefits from resource use mean that the goal of sustainable development remains doubly challenging from practical and political points of view.

Sustainability of ecosystem functioning: ecosystem health

1.4.9 More recently, discussion of sustainability has tended to focus on the notion of maintaining ecological *processes* at large geographical scale over many (human) generations. This view regards the maintenance of individual elements (species and populations) which make up ecosystems as of lesser importance provided that ecosystem functioning at the landscape level is not impaired. This view of sustainability is strongly linked to ideas of ecosystem health.

1.4.10 Within this context, ecosystem sustainability "implies the system's ability to maintain its structure (organization) and function (vigour) over time in the face of external stress (resilience)" (Costanza, 1992). These notions of ecosystem organization, vigour and resilience are central to most current discussions of ecosystem health. It is generally admitted that, as is the case with human and societal health, goals and definitions will be determined socially as much as scientifically. There will thus never be a single over-riding and incontrovertible objective.

1.4.11 This concept of sustainability can be seen as an attempt to synthesise ideas related to sustainable development with those concerned with sustainable use, direct or indirect, of natural resources. Intuitively it appears to offer one of the strongest frameworks in which to consider sustainability. Unfortunately its practical application is seriously hampered for a number of theoretical, practical and political reasons.

1.4.12 Many ecological processes operate over decades and therefore require long-term data series (ie. on this timescale) before it will be possible to begin to understand them. Even then, analysis of data available will at best generate hypotheses (often several competing ones) which need to be tested, preferably by experimental manipulation, again over time-periods of the same order of those of the processes being studied. However, activities affecting the environment and policy decisions controlling those activities are made over far shorter time-scales. There is no ready answer to this problem apart from again counselling a precautionary approach to the large-scale alteration of ecosystems and ecological processes.

1.4.13 Despite this problem, the concept of sustainability as the maintenance of long-term 'health' of ecosystems can certainly be considered as the ultimate goal. Although difficult to pin down, the concept does provide valuable insights, for example into questions of scale, both geographical and temporal, which are central to any discussions of sustainability. These are considered in more detail below.

1.5 TOWARD A SYNTHESIS OF APPROACHES

1.5.1 In the current absence of a firm scientific basis for objectively assessing ecosystem health, it is evident that a more pragmatic stance will have to be adopted, at least until a fuller understanding of ecosystem processes can be gained. The most practical option involves:

- reverting to the goal of *maintaining the elements of ecosystems* (species, populations, and their physical environment);

- *adopting a precautionary principle* so that as wide a range of species and ecosystems and as large an area of intact ecosystems as possible are maintained.

1.5.2 The precautionary principle, and different interpretations of it, lies at the heart of conflicts between conservation (the maintenance of biodiversity in all its facets) and other human activities. An extreme conservationist view would argue that no element of biodiversity should be lost or placed at risk, whatever the cost. Taken to its logical conclusion, this would entail the cessation of much present human activity and is clearly therefore an unrealistic proposition. At the other extreme there are those who would argue that efforts should only be made to maintain those aspects of biodiversity which are incontrovertibly demonstrated to be vital to human survival. This approach will ultimately lead to extreme biotic impoverishment of the biosphere, with unforeseeable consequences.

1.5.3 The most sensible course of action undoubtedly lies somewhere between these two extremes. It will essentially involve a trade-off between the benefits to be gained from maintaining some aspect of biodiversity (eg. preserving an area of virgin forest) and the costs in doing so, most of which are likely to be in the form of foregoing the benefits of conversion (ie. foregoing the financial gain from logging the area, plus the actual costs of maintaining it) (see, eg. Faith 1995). Determining where this trade-off should lie is one of the most problematic areas in biodiversity conservation: not only is it essentially socially determined, so that it will be based on the particular standpoints of those involved in the decision making, but the various costs and benefits involved are experienced very differently at different geographic scales and by different sectors of society. Establishing a consensus on what action to take is thus extremely difficult. This is discussed further below.

1.5.4 Scale is all important. The concept of sustainability can be approached at the global level (eg. Goodland *et al.* 1993), where uses of and impacts upon the entire spectrum of natural resources need to be addressed. At issue at this scale is the condition of ecosystems and ecosystem processes, and the future quality of life for humanity in general. At the other extreme, sustainability can be approached from the local or village level, where the availability of certain basic wild or agricultural biological resources needs to be addressed. At issue here is the status of local resources, and the survival or quality of life of individual people and communities.

1.5.5 Any given country will have to address issues of biological resource use at all these scales, from the local to the national. In the best of all possible worlds, each country would prepare a complete national biological resource audit, with detailed predictions of trends for all its natural resources over the whole range of temporal and spatial scales, from the local and immediate to the national and long-term. From this it would be possible to identify those areas where resources were being used unsustainably and to put into place remedial measures. Clearly in reality this is impossible to achieve. It is therefore vital that ways are

found for ordering priorities within countries, both for investigation and for action. Only in this way can there be any hope of effecting change in a realistic time scale.

1.5.6 Different aspects of biological resource use will be of differing importance in different countries and at the various scales. In particular developed countries are likely to have very different perspectives from less developed countries. Even within these groupings, there will be variation (eg. an LDC for which fisheries comprise a significant part of export earnings and GNP will have a different perspective on fisheries management from one where fisheries are only important locally, either for subsistence or for regional domestic markets).

1.5.7 Figure 1.1 illustrates very schematically some of these differences. It helps to demonstrate some of the reasons why it is so difficult to produce a single methodology for assessing the status of biodiversity and estimating whether its use is sustainable or not. It also highlights one of the central problems in biodiversity conservation, namely the wide disparity in perception between developed and less developed countries, which applies as much or more so to their respective citizens as to the nations as a whole.

Figure 1.1 Diagram to indicate the relative need for assessment of different kinds of biological resource at three geopolitical scales.

	WILD RESOURCES				DOMESTICATED RESOURCES		
	Intangibles	Ecosystem Services	Exploited resources		Ecosystem Services	Exploited resources	
SCALE			DCs	LDCs		DCs	LDCs
National	3	2	3	1	?	3	2
Provincial	2	3	2	2	?	2	2
Local Village	1	2	1	3	?	1	3

Key:
Numbers in cells indicate priority of needs: 3 (shaded) = top priority; 1 = least need.
Intangibles = option, existence, bequest values.
DC = developed country. LDC = less-developed country. These terms are for general comparative purposes only.

1.5.8 Any given country should address *all* the columns in this matrix to assess whether its use of biodiversity is sustainable or not. However, each column requires different emphasis and often a different approach. The remainder of this document discusses these different approaches. It is concerned particularly with wild resources rather than domesticated ones, although the latter are touched on with reference to genetic diversity. The document has also concerned itself with intangibles and exploited resources rather than with ecosystem services. A reliable theoretical framework for assessing ecosystem services has yet to be developed. In the absence of such a framework, it is believed that the best way forward is to address the other two major aspects of wild resource value as fully as possible.

2. A FRAMEWORK FOR SUSTAINABILITY ASSESSMENT

Summary

- *to help ensure a wide spectrum of biodiversity is maintained, two different but complementary approaches are needed: one concerned with maintaining the option and existence (intangible) benefits derived from biodiversity, the other focused on the direct use values;*

- *intangible benefits are best maintained by ensuring that ecosystems remain as healthy as possible, and persist in sufficient area: an efficient protected areas system is the best response to this need;*

- *direct use benefits can only be maintained by focusing on the resources in question; at the macroeconomic level marine fisheries and timber are by far the most significant sectors of use: not only are the products of great importance to humans but they are derived largely from wild resources;*

- *management of marine fish stocks requires an integrated ecosystem level approach, typified by the Large Marine Ecosystem concept, and needs strong international cooperation;*

- *inland fisheries are globally much less significant than marine fisheries, but locally provide essential food resources; the stocks are affected by habitat changes in the watershed, indigenous species are widely affected by the presence of introduced species; these systems also require ecosystem level analyses;*

- *assessment of the impact of harvest on populations of wild animals is usually problematic, particularly the task of clearly distinguishing the effect of harvest from those of environmental and stochastic factors;*

- *in practice, a decline in the number of large and old individuals in a population, or an increase in the effort required to attain a given harvest rate, have both been taken as indications of excess harvest;*

- *harvest of trees has a major impact on habitat structure and integrity; it is therefore particularly important that assessment of use of tree resources takes into account the wider impact such use has; principles and criteria for ecologically sound forest management have been developed by the Forest Stewardship Council.*

In accord with arguments developed in the previous chapter, two different but complementary approaches are proposed: one focused on ecosystem health and the less tangible values associated with this property, the other focused on directly used biodiversity resources.

2.1 PLANNING FOR THE LONG-TERM: MAINTAINING INTANGIBLE VALUES

2.1.1 Large-scale, long-term planning can be undertaken with the goal of maintaining ecosystem health, or, in economic terms, the less tangible values usually classified as the option, existence and bequest values of biodiversity. These values lie at the heart of arguments for the maintenance of biodiversity *per se*. That is, they are the principal justification for the maintenance of those parts of biological diversity which cannot be demonstrated to have

important immediate direct and/or indirect value. They are thus arguments invoked in the prevention of species extinction (particularly the conservation of threatened species) and the maintenance of representative samples of natural ecosystems.

2.1.2 From an individual country's point of view, sustainability of this sort is best viewed at the national level. This applies both to developed and to less developed countries. Each country should attempt to ensure that it minimises its loss of irreplaceable biodiversity (chiefly individual species but also habitats and ecosystems where these are known to be unlikely to regenerate naturally or difficult to restore artificially).

2.1.3 Central to this approach is the development of an adequate protected areas network, where maintenance of species and ecosystems takes precedence over other activities, although does not necessarily exclude them. The design and management of protected area networks is the subject of a large amount of literature which it would be unrealistic to attempt to summarise here. A suggested procedure for planning a protected area network with the aim of long-term maintenance of biodiversity follows. Major publications which provide practical guidance on these subjects are (full citations are provided (see References)):

Managing Protected Areas in the Tropics (Mackinnon *et al.*, 1986).
Marine and Coastal Protected Areas: A Guide for Planners and Managers (Salm, 1984).
Protected Landscapes: A guide for policy-makers and planners (Lucas, 1992).
Parks and Progress (Barzetti, 1993).
Guidelines for Protected Area Management Categories (IUCN, 1994).

2.2 PLANNING A PROTECTED AREA NETWORK

This section presents an outline of the main steps involved in planning a protected area network.

2.2.1 Assessment of national biodiversity stock

The first step is for each country to assess its natural resources and identify those which are most important, or in this context, most irreplaceable. Such an assessment should look at both species and ecosystems.

Priorities for species are, in order:
- Endemic threatened species;
- Endemic non-threatened species;
- Globally threatened species for which the country holds a significant part of the world population;
- Other globally threatened species;
- Nationally threatened populations of globally non-threatened species;

Priorities for habitats and ecosystems are, in order:
- Ecosystems unique to the country;
- Ecosystems for which the country holds a significant part of the world total;
- Species-rich ecosystems;

2.2.2 Identify important areas

Important species and habitats identified above should be mapped as accurately as possible to identify important areas.

2.2.3 Identify gaps

Gaps in knowledge will include both areas of the country which have been inadequately surveyed and groups of species which have been inadequately monitored.

2.2.4 Prioritise filling of gaps in knowledge

Resources available for ground surveys (and/or analysis of data from remote sensing) are almost invariably limited. It is important therefore that priorities are developed for field work before large amounts of effort are invested.

2.2.5 Systems review of current protected area network

Determine how much the existing protected area networks cover those areas identified as important for species and habitats (in the second step above (2.2.2)); determine gaps in existing Protected area network for such areas.

2.2.6 All the above steps essentially involve different aspects of *biodiversity inventory and assessment*. The various techniques to be employed in this are set out in detail in Chapter 3. Having determined *where* action needs to be carried out, the next, usually far more difficult step, is to determine *what* needs to be done practically to ensure that these biologically important areas are maintained.

2.2.7 Attempt to fill gaps in protected area networks

2.2.8 Determine threats to existing Protected areas

Priority to be given to those identified as important under step 2.2.2.

2.2.9 Determine means of alleviating threats identified

These are essentially questions of *policy,* and of assessing the *social and economic determinants* of land-use practices. Techniques for carrying out these forms of analysis are elaborated in Chapters 4 and 5.

2.3 PLANNING FOR THE LONG-TERM: MAINTAINING DIRECT USE VALUES

An effective protected area network is undoubtedly the best means available at present of maintaining the widest possible range of species and ecosystems. Other approaches have to be adopted for the maintenance and management of biological resources which are directly used. At a macroeconomic level, by far the most important sectors of wild resource use are fisheries and timber. Not only do these represent resources of great importance to mankind at a global level, but significant parts of each are derived from what is effectively wild stock: in the case of fishes, less than 10% of the annual global fisheries production of

around 100 million tonnes is from aquaculture. These two areas thus deserve special attention in any sustainability analysis.

Approaches to management of wild animals and plants are often different. The two will therefore be dealt with separately, in sections 2.4 and 2.5 below.

2.4 DIRECTLY-USED ANIMAL RESOURCES

2.4.1 Wild animals are harvested for a wide variety of reasons. By far the most important is food, but clothing (eg. leather, fur), medicines (eg. bones for oriental medicines), ornaments (eg. tropical fishes for aquaria), companion animals (eg. parrots as pets), sport (eg. trophy hunting), building material (eg. coral) are also sometimes important, as are a range of minor products such as dyes and wax. As with any commodity, products from wild animals may be used locally, transported within a country or traded internationally. They may be for subsistence use (consumed by those who harvested them), bartered or they may enter the cash economy. An overview of the various uses that wild animals are put to is provided in WCMC (1992), while a detailed treatment of the international trade in wildlife and wildlife products (excluding large-scale fisheries) is provided in Fitzgerald (1989).

2.4.2 As noted above, the harvest of finfishes and aquatic invertebrates is by far the most important type of harvest of wild animals. In principle, methods for assessing sustainability and developing management techniques are much the same as when dealing with terrestrial species. In practice the two tend to be different. In particular control of marine (as opposed to inland) fisheries is very different from control of terrestrial resources. This arises for a number of reasons, including the sheer scale of fisheries operations, differences between marine and terrestrial ecosystems and legal and practical differences between the control of extra-territorial (ie. international) waters and terrestrial and inland water areas which are strictly under national jurisdiction.

Marine Fisheries

2.4.3 Sherman and Busch (1995) discuss at some length the problems and challenges of assessing human use of marine ecosystems. They regard the concept of the Large Marine Ecosystem (LME) as central to such analysis (see Box 2.1). Many LMEs include the coastal waters of more than one state. In these cases, it will be effectively impossible for individual nations to assess whether their use of marine resources is sustainable in isolation from neighbouring nations. Coordination between states in monitoring and resource management will thus become increasingly necessary as the pressures placed on these areas increase. At present no single international body is in a position to coordinate action and reconcile the needs of individual nations operating within particular LMEs.

2.4.4 The need for an integrated, ecosystem-level approach to the management of fisheries stocks is underlined by the increasing awareness that fish population levels are determined by a wide range of interacting factors, both human-induced and natural, of which harvest levels are only one. Assessment of whether harvest of particular fish stocks is sustainable will depend on integrated monitoring, research and management programmes.

Box 2.1 Large Marine Ecosystems

Large Marine Ecosystems (LMEs) are "regions of ocean space encompassing near-coastal areas from river basins and estuaries out to the seaward boundary of continental shelves and the seaward margins of coastal current systems. They are relatively large regions of the order of 200,000km^2 or larger, characterized by distinct bathymetry, hydrography, productivity, and trophically dependent populations. Nearly 95% of the usable annual global biomass yield of fishes and other living marine resources is produced within 49 identified LMEs which lie within and immediately adjacent to the boundaries of EEZs of coastal nations (Sherman and Busch, 1995).

2.4.5 Critical questions to be asked include the following (from Beddington, 1984):

- What levels of mortality imposed by a fishery will permit a sustainable yield?
- Are there levels below which a fish population will not recover?
- Can judicious manipulation of the catch composition of the fishery alter the potential of the community to produce yields of a particular type (eg. high value species)?
- Can a community be depleted to a level where its potential for producing a harvestable resource is reduced?

2.4.6 Core monitoring activities include the use of Continuous Plankton Recorders (CPRs) for plankton and water quality assessment, bottom trawling for measuring changes in the fish community and environmental pollution assessments. Sampling and monitoring efforts undertaken by the Office of Oceanography and Marine Assessment of the US National Oceanic and Atmospheric Administration (NOAA) exemplify the range of information which should be gathered:

- systematic collection and analysis of catch-statistics;
- fisheries-independent bottom and midwater trawl surveys for adults and juveniles;
- ichthyoplankton surveys for larvae and eggs;
- measurements of zooplankton standing stock, primary productivity, nutrient concentrations;
- measurements of important physical parameters such as water temperature, salinity, density, current velocity and direction, air temperature, cloud cover, light conditions;
- in some habitats, measurement of contaminants and their effects.

2.4.7 As with most other aspects of sustainability assessment, long-term data series (on a time-scale of decades) are necessary to provide the data for analysis. Establishing cause-and-effect relationships will depend on complex and sophisticated modelling using these data, along with extensive hypothesis-testing including comparisons of areas under different management regimes.

Freshwater or inland fisheries

2.4.8 According to FAO estimates (FAO 1994) 1992 global inland fisheries catch from wild sources was around 6000 mt. This was less than one tenth estimated total marine catch from wild sources (around 80,000 mt) and less than total inland aquaculture production (around 9000 mt). Globally therefore they are of much lesser importance than marine fisheries. Locally they may be of great importance, both ecologically and economically.

2.4.9 As with marine fisheries, management of inland fisheries increasingly entails analysis at the ecosystem level. This is because these fisheries are affected at least as much by habitat modification as by fishery regimes. Important factors include pollution, siltation, canalisation, damming and abstraction of water. Inland waters are much more susceptible to most of these factors than marine waters, with land-locked or nearly land-locked seas (eg. Caspian, Black and Mediterranean) occupying an intermediate position. A major factor in many inland fisheries which is as yet of minor importance in marine fisheries is the presence of introduced species. These have often come to dominate fisheries production and have had far reaching and sometimes devastating impacts on aquatic biological diversity. There are few clear-cut solutions as yet to the problem of managing such systems to maintain high levels of production at the same time as preserving diversity.

Terrestrial animals

2.4.10 Globally, harvest of wild terrestrial animals is far less significant than fisheries, both in terms of its ecological impact and its importance to humanity. Locally this may be far from the case.

2.4.11 Uncontrolled hunting, usually for food, has been implicated as the main, and sometimes only, cause of a large number of extinctions, particularly of mammal and bird species (WCMC, 1992). There is growing evidence that hunting by local peoples is having a greater impact than habitat loss on wildlife populations in many parts of the world, particularly tropical moist forest regions in Africa, South-east Asia and South America (Bennett, 1994; Bodmer, 1995). In these areas wild-caught animals ('bush-meat') may make up a significant proportion of animal protein intake in the diet. In addition, hunting may be a culturally important activity which continues to be undertaken even when not necessary from the point of view of food-provision.

Assessing sustainability of animal use

2.4.12 Assessment of the impact of harvest on wild animal species is usually problematic. It is difficult, expensive and time-consuming to census populations of most animal species, especially over wide areas. Wild populations of all animal species invariably fluctuate owing to environmental variation and stochastic processes. These variations may be extremely marked. Disentangling such variation from that caused by human actions is problematic, and as with fisheries, generally requires time-series data running over many years and usually decades. Even then it is unlikely that unambiguous causal relationships can be established without experimental manipulation of environmental conditions.

2.4.13 Assessment of sustainability of harvest of terrestrial animal species is in one important respect less problematic than assessment of use of trees or aquatic animals. This is in the

broad context of ecosystem health. This is because terrestrial animals are in general less important components of the ecosystems in which they occur than are trees or marine animals of their ecosystems. Trees are essential structural components of the ecosystems they occur in, and they provide essential resources for a host of smaller organisms; their removal self-evidently has far reaching effects. Plants (with few exceptions) are also primary producers and therefore fundamental to the productivity of almost all ecosystems. Marine animals are the major components of most marine ecosystems, particularly those outside the photic zone (the surface layers of the sea which receive enough sunlight to allow photosynthesis and thus the existence of phytoplankton); harvest of these is therefore very likely to have far-reaching consequences. To this extent, therefore, it is more justifiable to examine sustainability of use of particular species or populations independently.

2.4.14 Care must be taken, however, not to neglect the impact that terrestrial animals do have on ecosystems. In some cases this may be very important (eg. the role of grazing herbivores in maintaining grasslands; the role of insects, bats and birds in pollination; the role of many species in seed dispersal). Harvest of some animal species may therefore have far-reaching impact on ecosystem dynamics. In addition many forms of wildlife harvest can have destructive effects on habitats (eg. tree-felling to collect wild honey; many fishing techniques).

Management of animal use

2.4.15 Management of wild animal harvest consists of some or all of the following:

- Control on harvest through:
  - Closed areas (permanent or periodic);
  - Closed seasons;
  - Limiting who is allowed to hunting (eg. only indigenous peoples; only hunting licence-holders);
  - Catch limits or quotas in terms of overall numbers of individuals taken per hunter or per licence, or numbers of particular age-sex classes;
  - Limitation on harvest techniques (eg. banning of certain types of nets or firearms).

- Management to improve breeding and/or survival rates:
  - Enrichment of wild populations (fish/game-bird hatcheries);
  - Provision of food/breeding sites/shelters;
  - Reduction of presumed predators.

As management of the latter sort becomes more intensive, so the situation tends more and more towards domestication.

2.4.16 The best way of estimating sustainable harvest levels is open to debate. There are two basic approaches: the theoretical model (based wherever possible on empirical data) and the pragmatic or indirect (in which various parameters of a population are monitored and its degree of exploitation inferred).

2.4.17 Wildlife biologists use one of two models of population response (Shaw, 1991): the *complete compensation model*, in which harvest has no real effect on a population until a certain threshold level is reached, above which continued harvest will drive a population to

extinction; and the *partial compensation model*, in which *any* level of harvest affects the population by depressing it beneath unharvested levels and by altering density-dependent responses, eg. decreasing natural mortality, increasing fecundity etc. Caughley (1985) concluded that the partial compensation model was more appropriate to most wildlife populations.

2.4.18 There are also two basic kinds of computer models of the behaviour of harvested populations under different sets of circumstances: *accounting models*, which focus on age-specific estimates of fecundity and mortality; and *stock-recruitment models*, which require only a few high-order variables such as population size and actual harvest, since they assume that these accurately predict the outcome of the numerous lower-order variables such as age-specific mortality and fecundity. Stock-recruitment models are generally favoured by wildlife managers (Shaw 1991).

2.4.19 In many real situations cruder and more pragmatic measurements may be used to infer acceptable harvest levels indirectly by monitoring the impact of current levels of harvest on population parameters (see Box 2.2). Because of the large margins of error associated with most population parameters, it is essential that the precautionary principle is applied in all cases, so that quotas or harvest levels set err on the side of caution.

Box 2.2 Some approaches to assessing harvest levels in animals

Animal Biomass/Age Structure

Bodmer *et al.* (1994) compared animal biomass (measured by multiplying average body weight by the density of individuals) and age structure of mammalian populations (measured by estimation of ages of skulls from hunted animals) in heavily harvested and lightly harvested areas of Amazonian Peru. In heavily harvested areas, some larger mammal species occurred at lower densities and had an age-structure strongly skewed towards young animals. Bodmer *et al.* concluded that these species were being used unsustainably and recommended the cessation of hunting of these species. A similar "age structure" study of the Western Atlantic Bluefin Tuna showed that from 1970 to 1990 the numbers of 'giant' adult tuna aged over 10 years old declined by 95% (WCMC 1992), indicating that levels of harvest were not sustainable.

Kill Rates/Catch Per Unit Effort

In an alternative approach Vickers (1991) estimated hunting levels in Amazonian Ecuador from kill rates of different species (ie. the numbers of kills per 100 man-hours of hunting per year) over a 10-year period. When a population is first made productive by cropping, its numbers and kill rates decline. Vickers considered that if the initial decline was followed by relatively stable kill rates over several years, data were consistent with that expected from sustainable cropping, whilst if kill rates declined steadily this implied a steady reduction in populations caused by over-exploitation. He found that the kill rates of the majority of animal species exploited by the Siona-Secoya, an indigenous community of Amazonian Indians living at near-aboriginal densities, were relatively stable over time, and concluded that they were being harvested sustainably. Such 'catch per unit effort' measures are also widely used to monitor the impact of harvest on fisheries.

Individual Body Mass

Another indirect approach is to measure the weights of hunted animals and compare with the distribution of weights in a non-hunted population, or the same population at an earlier point in time. In effect, the body mass approach relies on an indirect assessment of the age structure of the population. In hunted populations, adults live shorter lifespans and so reach lower final weights, and often a high proportion of juveniles is taken (Robinson and Redford, 1991). The average weight of animals from a heavily hunted population is therefore lower than that of a non-hunted or lightly hunted population.

2.5 DIRECTLY-USED PLANT RESOURCES

It is useful to distinguish between trees and non-woody plants. In terms of volume and economic value, especially at regional and national scale, plant use is nearly equivalent to use of trees and their products. On the other hand, the importance of non-woody plants should not be under-estimated, especially at local level.

Trees

2.5.1 A significant part of the use of trees involves removal of woody biomass. This changes habitat structure in a way which the vast majority of harvest of terrestrial animal species (and indeed of non-woody plants) does not, as the latter are not generally structural components of habitats. In terms of its ecological impact, therefore, harvest of trees is qualitatively different from other forms of terrestrial wildlife use. Assessing whether such activity is sustainable or not is correspondingly more problematic.

2.5.2 Analysis of direct use of trees has to take the following into account:

- The various uses trees are put to: timber (sawn-wood, veneers, poles, secondary wood products such as blockboards, chipboards); fuel (firewood, charcoal); fertilizer (slash-and-burn); fodder (branches, leaves); food (fruits, palm hearts, sago, exudates); medicines (roots, bark, leaves, flowers); others (rubber, oil, tannins, dyes, bark-cloth); pulp (for paper);

- Whether use is destructive or not;

- Where products are used: all above products can be used within country, exported or imported;

- Sources of products: plantations; managed natural or semi-natural forests; unmanaged natural forests;

- Land tenure of forest resource: national forest domain; subnational (state, province) forest domain; parastatal domain (eg. UK Forestry Commission); private; customary tenure; open access;

- Whether use is legal or illegal.

Assessing sustainability of tree use

2.5.3 There are four principal questions:

- Is the direct use of resources from trees as set out above sustainable at national and local levels?

- How does the use of tree resources affect the direct use values of other wild resources harvested from the area?

- How does the use of tree resources affect the option/existence values of habitats or ecosystems with trees in them?

- How does the use of tree resources affect the ecosystem services or indirect values of trees or the habitats and ecosystems which contain them?

2.5.4 Preliminary analysis has to be carried out at the national level. This will set the context for more specific regional and local analysis, bearing in mind that the situation can differ radically from region to region within a country. Essentially study should consist of a comparison of supply and demand, both at the time and projected into the future.

2.5.5 This requires an assessment of standing stock of different timber types with estimates of sustainable annual production, derived from measurements of production cycles in plantations and measured or estimated annual increments of harvested species in natural forests. Comparisons of production with measured and estimated demand allows sectoral shortfalls to be identified. Because the same resource can be used for a wide range of different purposes, studies of this sort are generally complex undertakings (see, for example, the analyses of Kenya's forestry sector in FAO/World Bank Co-operative Programme Investment Centre, 1989, and Marshall and Jenkins, 1994). They are nevertheless vital for any long-term planning.

2.5.6 Clearly it will not be feasible to look at local level use in detail throughout a country. Priorities therefore have to be determined. From the point of view of natural resource management (though not necessarily from the point of view of immediate amelioration of living conditions for the maximum number of people), important areas are:

- Those identified as important for option/existence values, particularly buffer zones around protected areas;

- Those where ecosystem services/indirect values of timber resources are known or believed important.

2.5.7 When priority areas have been identified, the local situation can be analysed by application of Rapid Rural Appraisal techniques (see Chapter 4).

2.5.8 Analysis of timber supply and demand will provide an answer to the first question in 2.5.3 above, ie. will give an indication of whether the timber industry is sustainable in a narrow sense. Answering the remaining three questions, ie. addressing the wider concept of sustainability, is a far more complex matter, for the reasons discussed in the introduction to this document.

2.5.9 As yet, there is no satisfactory, universal definition of the term sustainable used in the wider sense when applied to forest management and timber production. Organisations such as WWF and the Forest Stewardship Council (FSC) which have been heavily involved in the promotion of sustainable-use practices in forestry have instead generated a series of guiding principles and criteria for the wise use of forests (see Box 2.3).

Box 2.3 Forest Stewardship Council (FSC) Principles for Natural Forest Management

Principle 1: Compliance with laws and FSC Principles
Forest management shall respect all applicable laws of the country in which they occur, and international treaties and agreements to which the country is a signatory, and comply with all FSC Principles and Criteria.

Principle 2: Tenure and use rights and responsibilities
Long-term tenure and use rights to the land and forest resources shall be clearly defined, documented and legally established.

Principle 3: Indigenous people's rights
The legal and customary rights of indigenous peoples to own, use and manage their lands, territories, and resources shall be recognized and respected.

Principle 4: Community relations and worker's rights
Forest management operations shall maintain or enhance the long-term social and economic well-being of forest workers and local communities.

Principle 5: Benefits from the forest
Forest management operations shall encourage the efficient use of the forest's multiple products and services to ensure economic viability and a wide range of environmental and social benefits.

Principle 6: Environmental impact
Forest management shall conserve biological diversity and its associated values, water resources, soils, and unique and fragile ecosystems and landscapes, and, by so doing, maintain the ecological functions and integrity of the forest.

Principle 7: Management plan
A management plan - appropriate to the scale and intensity of the operations - shall be written, implemented, and kept up to date. The long term objectives of management, and the means of achieving them, shall be clearly stated.

Principle 8: Monitoring and assessment
Monitoring shall be conducted - appropriate to the scale and intensity of forest management - to assess the condition of the forest, yields of forest products, chain of custody, management activities and their social and environmental impacts.

Principle 9: Maintenance of natural forests
Primary forests, well-developed secondary forests and sites of major environmental, social or cultural significance shall be conserved. Such areas shall not be replaced by tree plantations or other land uses.

Principle 10: Plantations
Plantations shall be planned and managed in accordance with Principles 1 through 9, and the following criteria. Such plantations can and should complement natural forests and the surrounding ecosystem, provide community benefits, and contribute to the world's demands for forest products.

NB A detailed set of criteria for each of these principles is provided by the FSC.

Management solutions

2.5.10 The principles and criteria of the FSC provide a framework for developing wise management of forest resources. In practice, management solutions will entail some or all of the following:

- Reducing demand by:
  reducing level of the activity;
  increasing efficiency of activity;
  finding substitutes;

- Increasing supply by:
  diverting from other uses;
  increase harvest to non-sustainable levels (short term);
  increase efficiency of management or increase in area of plantations (long-term);
  import.

2.5.11 Constraints on these solutions:
capital investment required to implement changes;
human resources necessary;
political will necessary;
limits to transportation or alternative resources;

2.5.12 The very last of these is the major reason why analysis has to be carried out regionally and locally as well as nationally. In most LDCs, transportation networks are inadequate and transportation costs very high. Moreover, where use is subsistence or at the lower end of the cash economy, users will not be able to afford products which have been transported any distance. Generally the less developed the country, the more important it is to look at the local (village) level. This is discussed in more detail in Chapters 4 and 5.

2.5.13 The economic and social consequences of unsustainable use of tree resources are likely to be very far-reaching. They will ultimately lead to the restriction or cessation of the activities dependent on them, or result in a switch to other resources. This may have knock-on effects (eg. change to dung as fuel resource leads to loss of fertility of soils; migration; famine).

2.5.14 Solutions to local shortage or unsustainable use may well involve improvements in transportation networks (including perhaps transport subsidies) but these can only help in the short term or if entire country or region under consideration is in surplus (or at equilibrium at worst). The situation is likely to be complex and results of changes counterintuitive (eg. improving transport systems may cause local people to turn to natural forests for fuelwood because they can no longer afford charcoal from plantation areas because this is being transported to large towns, pushing prices up). Where major pressures are local, solutions will almost certainly entail improved community management of resources.

Plant resources that are not trees

2.5.15 Non-woody plants may be used for many of the purposes outlined above with respect to woody plants (apart, of course, from the provision of timber and other wood products). Perhaps the single most important use is as grazing for livestock on rangelands and other areas of unimproved grassland. Second in importance is probably the use of wild plants for medicines. In many LDCs the vast majority of medicines used by most of the population are derived from wild plants. In addition in many predominantly agricultural societies, various forms of wild food (usually plants) may be of great importance as emergency foods in times

of famine. Because their use is intermittent, their importance tends to be underestimated in conventional economic analyses (see Chapter 4).

2.5.16 An overview of the uses of wild plant resources is provided in WCMC (1992). A discussion of the international trade in wild plants is provided in Jenkins and Oldfield (1992). Although this trade is of much lower volume than domestic use of plants it may have a disproportionate effect on the conservation of species as a large part of it, particularly the ornamental plant trade, will concentrate on rarer wild species.

3. INVENTORY AND ASSESSMENT OF BIODIVERSITY

Summary

- *select and prioritise data requirements according to national strategic goals and the UNEP Country Study Guidelines;*

- *emphasise endemic species, threatened species and resource species, including importance to human communities, rates of use and of loss;*

- *attempt to identify geographic areas rich in such species, and areas where human use of them is critical;*

- *identify sources of existing data; undertake research to fill gaps in information; aim to set a baseline in order to monitor and identify trends;*

- *assessment of habitat change at global level is hindered by lack of a standard habitat classification; assessment at national level and below requires at minimum an internally consistent scheme (that need not apply elsewhere);*

- *the status of individual species is best assessed using the revised IUCN/SSC category system which is being enhanced to apply at national as well as global level; evaluating genetic erosion is of particular importance for biological resources, including domestic species, local varieties, and their wild relatives, but is technically demanding;*

- *a large number of techniques have been developed for rapid biodiversity assessment, several based on extrapolation from occurrence of indicator groups.*

3.1 INTRODUCTION

3.1.1 Issues relating to trends in elements of biodiversity and the sustainability of biodiversity use can be addressed most precisely on the basis of inventory and subsequent repeat observations. This fundamental fact underlies the need for baseline surveys of national biodiversity resources and their uses. In many cases, the first assessment for biodiversity sustainability will have to serve as a base line, as much of the required information will not have been compiled previously; efforts should always be made to identify existing data and studies which might serve as partial baseline. Although quantified time-series data are preferable, less rigorous or sometimes even anecdotal evidence can be valuable. The process of determining what information is needed, how it could be managed, and what institutional capacity is required, has received much attention in recent years, and is summarised in UNEP's *Guidelines for Country Studies on Biological Diversity* (UNEP, 1993).

3.1.2 Sources of existing information may cover biodiversity at the local, national, regional or global level; may be published or unpublished (reports, databases or digital files); and may be held in-country or externally. In-country sources of information may include national museums, universities, agricultural development agencies, government departments (particularly forestry and wildlife), non-governmental organisations (NGOs) and the private sector. Because of the variety and number of such potential information sources it is not possible to give specific guidance in this document; in some cases external organisations

might provide an efficient route to finding in-country sources. Examples of predominantly external sources of global data are provided in Annex E of the *Guidelines*.

3.1.3 This chapter focuses on methods used to assess biodiversity in the broad sense. This assessment provides the basis for investigation of status, threats and uses, which all need to be addressed in the process of sustainability appraisal. Types of Rapid Rural Appraisal, introduced in the next chapter, are suitable for identification of users of biological resources, and these studies will in general also identify which resources are present and of socio-economic importance.

3.1.4 Given this general background, there are three basic issues that must be addressed:

- which data are needed?
- how best to collect them?
- what to do with them?

3.2 UNEP COUNTRY STUDIES GUIDELINES

3.2.1 It was recognised in development of the Convention on Biological Diversity that participating countries would need a national assessment of biological diversity to set a baseline for development of national strategies and action plans. An Expert Advisory Team for Country Studies on the 'costs, benefits and unmet needs for conservation and sustainable use of biological diversity' was established by UNEP. The document, *Guidelines for Country Studies on Biological Diversity*, was prepared in order to assist countries undertaking such studies.

3.2.2 The Technical Annex to the *Guidelines* provides details of the types of data recommended for inclusion in the Country Study, divided into four sections: socio-economic factors affecting biodiversity; biological data; assessment of benefits, costs and net monetary values of biodiversity; and current capacity for biodiversity conservation and sustainable use. The fifth section of the Technical Annex contains a directory of international sources of appropriate biodiversity data that may possess information pertinent to individual countries.

3.2.3 The *Guidelines* suggest how to determine what information is needed for a Country Study, how to manage it, and how to identify gaps in existing institutional capacity, but specify that individual countries are responsible for selecting elements for application in their Country Study. Empirical studies (eg. Metroeconomica Ltd., 1994) have shown that, institutional issues aside, collection of a significant proportion of the data covered by the *Guidelines* is much too demanding; it is thus critical to define a minimum set of data in relation to specific goals of a biodiversity strategy. *Where funds and staff are limited the importance of the need to select the most critical data for compilation or collection cannot be over-emphasised.*

3.3 CATEGORIES OF DATA REQUIRED: HABITATS

3.3.1 Habitat loss and modification is the major factor causing the current decline in the world's biodiversity (WCMC, 1992). Habitat monitoring is therefore important in any national assessment of biodiversity sustainability. Key requirements of habitat monitoring are:

- Mapping of current extent of habitats
- Estimation of change in the area of each habitat type over a specified time period
- Estimation of change in the condition of habitats

3.3.2 Habitat monitoring is technically difficult and made more so by the lack of universally accepted habitat or ecosystem definitions and classification systems. Habitats are usually defined by reference to the major plant species of which they are composed, often in conjunction with notable structural, topographic or geological features. The problem is that species distributions intergrade gradually, and boundaries between particular assemblages of species are almost impossible to delimit. In practice, habitat types are usually taken as corresponding to vegetation types, and the same caveats apply to the classification of both. It is also important to distinguish between systems that attempt to map potential vegetation (ie. before major human impact) from those that attempt to map actual vegetation as it presently stands. These approaches have different applications, but in the context of biodiversity assessment, the latter is needed. Box 3.1 notes some of the criteria that have been employed in vegetation classification.

Box 3.1 Some criteria used in habitat classification

Numerous habitat classification systems exist, focusing primarily on vegetation characteristics (UNEP/WCMC, 1996). The main criteria applied in these classification systems are:

- Physiognomic: features of height, growth form and coverage of vegetation
- Bioclimatic: the prevailing climate regime
- Phenological: leaf retaining characteristics (ie. whether vegetation is deciduous or evergreen)
- Floristic: occurrence of certain principal plant taxa
- Functional: management use (eg. fuelwood production)

Many schemes involve a combination of the above or include other parameters which affect vegetation cover such as land use, disturbance history, soil type or geology. Classifications may indicate the actual vegetation present, or indicate the 'potential' vegetation that would occur in the absence of human activity.

3.3.3 A sample definition of one particular habitat type and its loss is that given by FAO, who recently produced estimates of forest area and annual deforestation rates for over 85 tropical countries (FAO 1991, 1993). Forests were defined as: "*ecological systems with a minimum of 10% crown cover of trees and/or bamboos, generally associated with wild flora and fauna and natural soil conditions and not subject to agricultural practices*"; while deforestation was defined as: "*change of land use or depletion of crown cover to less than 10%*".

3.3.4 Habitat classification systems have been developed at a number of scales: global, continental, national/local systems. Scale obviously determines applicability: global scale schemes are too coarse (have too low a resolution) for national level planning, and local level detail is unwieldy at the continental and global level. It is important that whatever habitat definitions

are used for national biodiversity assessments are adhered to throughout the time series of measurements from which rates of habitat change are calculated. Many countries have undertaken national vegetation surveys and produced maps of vegetation types. From these, a table can be derived showing:

- Area of each vegetation type
- % of country total area it comprises
- % of each vegetation type protected in national parks or protected areas

3.3.5 Several basic principles are involved in the measurement of habitat *change*. First and foremost is the necessity for a consistent series of measurements taken over a period of time, from which rates of habitat change can be determined. Coarse scale habitat losses (for example decreases in forest cover) can be most easily measured by remote sensing. One very powerful technique for rapid and cheap assessment of large areas is satellite imagery, but systematic reconnaissance flights (SRFs) can be useful in smaller areas and for visually confirming satellite-derived data. Finer scale investigation is necessary to adequately inventory and monitor less extensive habitats, such as wetlands and freshwater systems, and to determine the extent of habitat modification, for example changes in understorey vegetation.

3.3.6 Stratified sampling, combining 100% coarse satellite coverage with 10% finer aerial survey and 1% detailed ground truthing may be the most cost-effective approach (J. MacKinnon, *in litt.*).

3.3.7 Definition of habitat condition tends to be highly purpose-dependent. For example, a forester may be interested in standing woody biomass in the forest, its size-class distribution and the incidence of commercial species; an ecologist may be concerned with ecosystem function (eg. nutrient and water cycling); whilst a conservation biologist may be interested in the integrity of the habitat and the variety of plants and animals that it supports. Each might therefore choose different indicators of habitat condition.

3.3.8 For most purposes, forest integrity (as a habitat and for maintaining ecosystem function) and biodiversity are useful indicators of forest condition. Pristine forests usually have high structural integrity (they are continuous in large blocks) and high biodiversity. Anthropogenic disturbance often reduces both integrity and biodiversity, but its intensity and frequency determine the nature, magnitude and duration of its effects, and in many habitats selective human uses (eg. coppicing of deciduous woodland or grazing of chalk grassland in Europe) can increase biodiversity. Severely degraded forests have greatly reduced biodiversity and structural integrity relative to pristine forests of the same region, and have a limited recovery capability (see Box 3.2).

3.3.9 Various techniques have been developed for measuring the extent of habitat fragmentation, although how this actually translates in terms of threat to biodiversity is not known. Most use remotely acquired data: satellite images, aerial photos or good maps. Several different indices to measure forest fragmentation have been developed in the past few years, two of which (the Perimeter Area Index) and the edge/core ratio (ECR) were used by FAO. Full definitions are given in FAO (1993). These indices could of course be applied to other habitats.

Box 3.2 Some potential indicators of forest degradation

Forest degradation which does not cause actual deforestation usually involves one or more of the following factors:

- Changes in species composition
- Changes in canopy cover
- Changes in age-structure of particular species

These can be monitored by field plot sampling. Other indicators of forest condition include changes in population sizes of individual species; forest 'health' ie. incidence of disease, pests and pollution; canopy structure (which can be remotely-sensed) and spatial change, eg. fragmentation. Field-measured indicators of habitat condition are useful at the site level and perhaps at broader scale in some locations, but the data are limited to relatively small areas. National level assessments of habitat condition need to be based on indicators that are more easily and widely available. Suitable condition indicators for forests are:

Integrity Spatial information, such as forest extent, fragmentation (perimeter/edge ratios, fragment size distribution, degree of isolation, connectedness); adjoining vegetation type or land use; canopy continuity.

Temporal information Stability over time (in terms of 'quality', configuration and context).

Biodiversity In the absence of complete species inventories, the status of key species or species groups (eg. primates, saproxylic ivertebrates, raptors) may provide insight into habitat condition.

Socio-economic Eg. distance to nearest population centre of a given size; distance from roads/river access; land tenure; government colonisation/settlement programmes, etc.

Habitat loss and reduction of species richness

3.3.10 Habitat loss may reduce levels of biodiversity by eliminating species or communities restricted to particular geographic localities; by decreasing the area of available habitat below the minimum size required to maintain ecological processes; and by decreasing species populations below the minimum viable population size, leading to local extinctions (see Box 3.3).

3.3.11 The effects of habitat loss may be compounded if habitat fragmentation (an indirect result of habitat loss) occurs, ie. if the remaining habitat consists of dispersed patches separated by converted areas. Small populations of species confined to habitat fragments are extremely vulnerable to extinction in the medium to long term due to restriction of seasonal or occasional migration patterns, isolation from immigrants (which can often 'rescue' a declining population), and chance demographic and genetic factors. Studies have shown that certain species will be less able to tolerate habitat fragmentation than others, and the effect will operate independently of the species loss predicted by the species-area relationship. Effects are likely to be major, but are currently unpredictable (Simberloff, 1992). Thus a seemingly large area of heavily subdivided remnant habitat may have less conservation value than a smaller but distinct area.

Box 3.3 Habitat loss and species extinction

Knowledge of the extent of habitat lost can be used to predict the resulting reduction in species diversity, since direct scientific observation has found that the number of species in a given area tends to be proportional to the size of the area. This is partly an effect of sampling (ie. a given habitat with randomly distributed species will become more completely inventoried as the area sampled increases) and partly because larger areas tend to have greater habitat diversity and thus a greater variety of species.

The 'species-area relation' is a mathematical expression of this finding, usually expressed in the form $S = CA^z$ (where S = the number of species, A = area, while C and z have different values for each set of species-area data). The converse relationship is that if an area of habitat is reduced in size, the number of species present will decrease. The most widely-quoted generalisation is that the loss of 90% of a habitat will result in the loss of approximately 50% of the species originally present.

Estimates of habitat loss (particularly rates of tropical forest loss) coupled with biogeographic theory have been used by a number of workers to estimate projected global extinction rates. There are a number of theoretical problems with this approach (WCMC, 1992), and caution must be exercised in interpreting results. One of the most recent estimates (Reid, 1992) predicts that 2-8% of the planet's species will become extinct in the next 25 years.

3.4 CATEGORIES OF DATA REQUIRED: SPECIES

3.4.1 It will not be cost-effective to attach high priority to compilation of a complete inventory of every species in every higher taxon present in a country. Key requirements are the identification of areas of high species diversity, coupled with identification of priority areas for action on the basis of threat assessment. Inventory of threatened species, endemic species, and economically or socially important species (including wild relatives of domestic species) will in general be priorities for data collection. It will be feasible to concentrate on the relatively well-known taxa, such as vertebrates, higher plants and certain groups of invertebrates such as butterflies and dragonflies, as indicators of biodiversity in general, but the extent to which this is legitimate has not been established. It might be appropriate to devote resources to taxonomic inventory of other groups at a later date. The *Guidelines* suggest that the first step in a Country Study should be to assess the *available* information on parameters listed below (a shortlist of these is suggested in Chapter 2 above).

- Species threatened with extinction, assessed using an internationally accepted system of threat categories (eg. IUCN, The Nature Conservancy (TNC))
- Country-endemic species whose conservation is the sole responsibility of that country
- Economically or socially important species
- Indicator species and keystone species of pivotal importance in ecosystems that can serve as measures of their disturbance or condition
- Landraces, varieties and wild relatives of domesticated species which require conservation measures
- Species present in existing conservation areas
- Species held in *ex situ* collections within the country

- Flagship species used to generate support for conservation actions
- Legally protected species - those mentioned in national legislation or on international conventions to which the country is a contracting party
- Other species present in the country, concentrating on scientific and common names, distribution and preferred habitat types (including breeding status in the case of migratory species)

Threatened Species

3.4.2 Declining species all face eventual extinction if negative trends in their populations are not reversed. Various programmes have developed methods of categorising the severity of threats facing a species. The threat categories assigned are used as a conservation tool to detect species at risk; activities can then be prioritised as appropriate. IUCN developed a system of threat categories through its Red Data Book and Red List programme. The IUCN system of threat categories has since become an accepted world-wide standard.

3.4.3 IUCN classify the severity of the threat of extinction faced by species based on a review of the factors affecting them and the extent of the effect that these are having throughout the species range. IUCN threatened species categories are applied to species on a global scale, but have been widely adopted by countries preparing lists of nationally threatened species. The original definitions of the categories of threat used in Red Data Books and similar documents lacked objective criteria.

An entirely new system has been designed, intended to provide an objective framework for the classification of species according to risk of extinction, and to be applicable across all relevant taxa (IUCN/SSC 1994). To be categorised as threatened, any species has to meet one of five sets of criteria, and the criteria (including population reduction, population size, geographic area and pattern of occurrence, and quantitative population analysis) have been formulated with the aim of allowing all kinds of species, with a wide range of biological characteristics, to be evaluated. The new system can, with appropriate qualifications, be applied to any taxonomic unit at or below the species level, and within any specified geographical or political area. It was approved by the IUCN council in November 1994 (see Annex 3).

Population and Habitat Viability Analysis (PHVA)

3.4.4 A second system of examining species conservation priorities is the Population and Habitat Viability Analysis (PHVA) workshops organised for particular species or groups of species by the Captive Breeding Specialist Group (CBSG) of IUCN's Species Survival Commission (SSC). The workshops assess the status of the species in the wild, use genetic and demographic models to give quantitative estimates of the risk of extinction under various scenarios, and, most importantly, make management recommendations based on these predictions.

3.4.5 The types of data used in assigning IUCN's new Red List categories are very similar to those used in the process of evaluating the population viability of a species, population of a species or subspecies in the PHVA workshops organised by CBSG. A PHVA assessment

for each species consists of an in-depth analysis of information on the life history, population dynamics, ecology and population history of the individual populations, coupled with information on threats, habitat and protected area.

3.4.6 Two key features of PHVAs are the use of non-published data derived from assembled experts; and the construction of simulated models of each population to ascertain the likely effects of deterministic and stochastic events on population dynamics and extinction risks. The likely effects of potential management options on population survival can also be modelled, enabling conservationists to select the least damaging or most beneficial alternative.

3.4.7 A drawback to the PHVA approach is that the models used require a knowledge of a great many parameters of the ecology and life history of a species. These may be accurately measured for small populations of well-studied species and captive populations, for which the models are appropriate. However, their predictive power is greatly weakened when applied to populations of the majority of wild species, whose conservation status and reproductive parameters are shrouded in uncertainty.

3.5 CATEGORIES OF DATA REQUIRED: GENETIC DIVERSITY

3.5.1 The genetic diversity within a population is fundamental to its ability to evolve and adapt to environmental change, and its maintenance is recognised as a high priority in many conservation programmes.

3.5.2 The loss of genetic diversity ('genetic erosion'), is widely recognised as a serious threat to biodiversity. It can harm both wild and domestic species, but certainly has serious implications for agricultural productivity. During centuries of domestication and selective breeding, agricultural species have become progressively more diverse genetically in parallel with increased adaption to local environmental conditions. This genetic variation is manifest in the large number of distinct sub-species, breeds, varieties and land races of food crops and domestic livestock. During the present century the number of distinct populations has declined.

3.5.3 There are two main causes of reduction in agricultural genetic diversity. Firstly, local breeds and varieties have been neglected or abandoned in many countries in favour of introduced, high-yielding modern crop cultivars and domestic stock. The result is the disappearance of genetic diversity. For example, in Greece, 95% of the native varieties of wheat have been lost in 40 years (Davies, 1991). This may reduce potential for the future selective breeding of crops and livestock better adapted to new, as yet unpredictable, environmental conditions. In the case of crop plants, highly-bred crop cultivars tend to require heavy inputs of agrochemicals, and excessive reliance on genetically almost uniform crops can be a high-risk strategy in the event of pest attack or adverse weather. Secondly, populations of wild relatives of agricultural species are being drastically reduced or lost altogether. For example, around 90% of the Ethiopian highland forests which harbour the wild coffee *Coffee arabica* have been destroyed, and large parts of the centre of genetic diversity of wild cocoa *Theobroma cacao* in Colombia, Ecuador and Peru have been lost to agricultural expansion which often follows in the wake of petroleum exploration (WCMC, 1992).

3.5.4 Genetic erosion is also a threat to wild species that have been reduced to small, fragmented populations. Both the number of individuals surviving and their genetic diversity or heterozygosity are important to population survival. In the short term heterozygosity is positively correlated with individual fitness, and in the long term genetic diversity is necessary for evolution by natural selection to occur. Genetic diversity can quickly be lost by breeding with closely-related individuals, which leads to low levels of heterozygosity and reduced offspring fitness, a phenomenon known as in-breeding depression. Various workers have examined the minimum viable populations (MVPs) of species required to guard against the negative effects of in-breeding in isolated populations. Suggested MVPs differ according to the species examined. As a rough guide, Lande and Barrowclough (1987) suggest an effective population size of 500 for large mammals.

3.5.5 Genetic diversity is impossible to quantify as a general property, but key parameters such as karyotypic variation, mitochondrial DNA divergence or protein polymorphisms can be measured. The first widely-used genetic survey technique for detecting molecular level variants was protein electrophoresis, introduced in the mid-1960s. This method can provide information on how many alleles there are at a locus, their frequencies within a population and their geographical distribution over the species' range. It is however only applicable to those sections of DNA within the genome which code for the production of protein (usually soluble enzymes).

3.5.6 A number of new techniques have recently become available, such as DNA fingerprinting, the polymerase chain reaction (PCR), restriction site mapping and DNA sequencing (see Box 3.4). These have a number of advantages over protein electrophoresis (Templeton, 1994). They have greater resolution and some can be applied to both coding and non-coding sections of DNA, allowing investigation of the entire genome rather than just a small subset. The last two techniques can also allow inference of evolutionary relationships. Such methods to measure genetic diversity within or between populations require many samples and analysis by trained personnel using sophisticated laboratory techniques.

3.5.7 Genetic diversity is not therefore the normal currency in which biodiversity is measured. UNEP recommends that biological data on biodiversity are primarily collected at the species level, and that subspecies, populations and genetic diversity *per se* are only considered where they have some significant economic value or indigenous use, for example as sources of genetic material useful in crop or breed improvement.

Assessing genetic erosion

3.5.8 The actual measurement of genetic erosion is problematic, since it requires the establishment of a baseline against which to measure. A suggested procedure would be as follows: if variability in the phenotype can be taken as an indication of variation in the genotype, measurement of genetic erosion could consist of a comparison of the number of recognisably distinct breeds or varieties present at some time in the past with those still present now. This measure could be coupled with an assessment of the degree of threat currently facing the existing breeds or varieties (eg. Loftus and Scherf, 1993), to allow the prediction of potential future genetic erosion in the absence of conservation measures.

Box 3.4 Measures of Genetic Diversity

Several different measures of genetic diversity exist.

Percent of polymorphic loci (*P*): A locus is commonly defined as polymorphic if the frequency of its most common allele is less than 0.95. If *p* loci out of *n* are polymorphic, the percent of polymorphic loci is simply $P = 100\ (p/n)$.

Number of alleles (*N*): The number of alleles at a particular locus.

Heterozygosity (*H*): Two different measures are used.

> *Observed heterozygosity* is the probability that an individual will be heterozygous at a locus. It can only be applied to diploid genetic elements, and is even then not suitable for all situations. For example, in a population of 100% self-fertilising plants, observed heterozygosity will be close to zero for all loci, regardless of how many alleles they have or the frequency of those alleles.
>
> *Expected heterozygosity* (the more commonly used measure) is the probability that two copies of a locus drawn at random from the gene pool have different allelic states. It can be applied to both diploid and haploid genetic elements, such as mitochondrial DNA.

Average number of nucleotide differences (*K*): restriction site and DNA sequence techniques allow the estimation of the average number of nucleotide differences between two genes drawn at random.

Number of segregating sites (*S*): the number of restriction sites or nucleotides that are polymorphic in the DNA region under study.

Source: modified after Templeton (1994).

3.5.9 In trees and agricultural crop plants, genetic diversity can be measured by two methods: provenance testing and allozyme screening (CMGGRAI 1991). Provenance testing involves the collection of seeds from different populations (usually from different geographic and climatic regions) and their growth under uniform environmental conditions at one or more sites. Results of these experiments provide data on the variation among populations in survival, growth, productivity and qualitative characteristics, and enable assessment of the importance of the genotype-environment interaction. This indicates the extent to which populations should be conserved separately and also bred separately in future.

3.5.10 Priorities for the conservation and management of genetic resources can still be set in the absence of a genetic erosion measure, given a knowledge of the level of genetic diversity among and between specific populations, or (and this will usually be more feasible) on the basis of phenotypic diversity. To date most efforts have focused on agricultural plants, and relatively little work has been done on agricultural animals.

3.6 METHODS FOR COLLECTING NEW DATA

3.6.1 In the last decade a number of techniques have been developed for the inventory of biodiversity. These techniques have been applied at both national and sub-national levels in various efforts to identify priority areas (those of high biodiversity or possessing large numbers of restricted-range or threatened species) to which the limited funds available for conservation should be directed. Most techniques are referred to by acronyms, which tend to be associated with particular conservation organisations (eg. RAP developed by Conservation International). There is a profusion of acronyms (eg. RAP, RBA, REA, CBW) but often little fundamental distinction between the methods. Most techniques focus on the species as the measurable unit of biodiversity. In effect they target species diversity and ignore subspecific diversity, taxonomic distinctness and other aspects of biodiversity.

3.6.2 Some of the more prominent biodiversity assessment techniques are summarised below. These techniques rely on the compilation of existing data, the collection of new data, or, as in the majority of cases, both. Data compilation, during which existing information from a variety of sources is synthesised to provide an overall view of the known state of biodiversity, is an important phase of all national-scale biodiversity assessments. From this analysis priorities for conservation or further data collection can be identified. Consultation with national and international experts is an explicit and integral part of the data compilation process in two techniques: Conservation Biodiversity Workshops and Conservation Needs Assessment. Both methods invite participants to workshops in order to capture existing biodiversity knowledge. The aim is to build consensus on existing data, data requirements and conservation priorities. Consultation with selected experts is probably also an implicit part of other techniques, but is not as formalised.

3.6.3 The collection of new data may be conducted on the ground, or remotely *via* satellite or aerial survey. Remotely-sensed data are usually only applicable to the monitoring of habitats: species distributions and status must be ascertained by direct investigation at ground level. Collection of new data is an essential component of all site-specific assessments (eg. All Taxa Biodiversity Inventory).

3.6.4 Baseline biodiversity inventory techniques attempt to provide an overview of the species composition of particular areas. Two operating principles, used separately or in combination depending on the scale of the area inventoried, are fundamental to biodiversity inventory techniques: use of indicator groups and use of extrapolation.

Use of Indicator Groups

3.6.5 The variety of living species in even a small area is so great that the identification of all species present is impracticable. Certain taxa are therefore chosen as 'indicator groups' (also sometimes referred to as 'biodiversity surrogates' or 'predictor sets') assumed to be representative of total biodiversity. No one organism or group of organisms can be expected to comprehensively reflect the patterns of distribution and abundance of all other taxa. However, Noss (1990) and Pearson (1994) have developed a number of biological and logistical criteria which they suggest should be considered during the selection of indicator groups, in order to maximise their usefulness (see Box 3.5).

Box 3.5 Features of potential indicator groups

Desirable indicator groups should be:

- Taxonomically well-known so that populations can be reliably identified and named
- Biologically well-understood
- Easy to survey (eg. abundant, non-cryptic) and manipulate
- Widely distributed at higher taxonomic levels (eg. order, family, tribe, genus) across a large geographic and habitat range
- Diverse and include many specialist taxa at lower taxonomic levels (ie. species, subspecies) which would be sensitive to habitat change
- Representative (as far as is known) of distribution and abundance patterns in other related and unrelated taxa
- Actually or potentially of economic importance

Source: modified after Noss (1990) and Pearson (1994)

3.6.6 In addition, it is highly desirable that indicator groups should consist of taxa which can readily be discriminated to at least species level in the field (without recourse to museum collections) by non-experts after a minimal amount of training. Such 'parataxonomists' are increasingly used in many biodiversity inventory techniques. Pearson (1994) suggests that the order of importance of the criteria above in the selection of indicator groups differs for biodiversity monitoring and biodiversity inventory, and proposes a method of calculating a standard index to determine the suitability of potential indicator groups to each task. Common indicator groups used in biodiversity inventories are higher vertebrates (eg. mammals, birds), certain invertebrate groups (eg. butterflies, ants, land snails) and higher plants (particularly trees). Care should be taken in interpreting the results of inventories based on indicator groups since the empirical relationships between biodiversity in different groups of organisms (eg. between vertebrate species and fungi, or invertebrates and higher plants) has been little investigated.

Use of Extrapolation and Prediction

3.6.7 It is impossible in practice to inventory every site. However, knowledge of species habitat requirements, coupled with baseline data on climate, altitude, soil type, or vegetation cover, can be used to predict their occurrence in areas not inventoried. A geographic information system (GIS) is commonly used in biodiversity inventory techniques. GIS can be employed to generate maps of the expected distribution of species from maps of the key environmental factors known to affect their distribution. Analysis of maps of species ranges superimposed allows the identification of areas potentially high in biodiversity. These predictions can be verified (or 'ground-truthed') if required by field surveys. The baseline GIS maps used may be generated from satellite data, aerial survey, and existing maps, or created by field survey and expert advice. A major advantage of GIS is that it enables the standard formatting of all maps used, no matter what their source. Use of GIS implies an advanced and highly

technical approach; this will not always be preferred, particularly where capacity of the personnel involved is not appropriate and where staff continuity cannot be secured.

3.6.8 The key features of some of the techniques available are summarised below and in Tables 3.1 and 3.2. Further details and brief synopses of the pros and cons associated with each technique are given in Annex 2, which is based on analysis of published reports. Whether those techniques which can be applied nationally are suitable for a particular country depends largely on its size. Other factors involved include the extent of existing technology and expertise in-country, the degree of funding available, and the time-frame in which a national-scale analysis is required.

3.6.9 The goal of baseline biodiversity inventories, whether conducted at the local or national level, is not, generally speaking, to produce a complete but static picture of national biodiversity. It is rather to facilitate comparison between sites to enable the prioritisation of scarce conservation or development resources, and to act as a catalyst to further study and inventory. In practice therefore, the conduct of a national biodiversity baseline inventory may involve the simultaneous or sequential application of several of these techniques. For example, a Conservation Needs Assessment might classify sites into a graded system of immediate conservation priorities; locate unstudied areas in which Rapid Assessment Programme inventories were required; and at the same time identify a need for Rapid Biodiversity Assessments to determine future priorities in a series of relatively well-known sites of apparently equal biodiversity.

Table 3.1 Processes involved in biodiversity inventory techniques

<table>
<tr><th colspan="3">NATIONAL LEVEL</th><th colspan="2">SITE LEVEL</th></tr>
<tr><td>Consultation with national and international experts</td><td>Compilation of existing data</td><td>Identification of national priorities and new data needs</td><td>Collection of new field data at multiple sites</td><td>Collection of new field data at a single site</td></tr>
<tr><td colspan="3">CNA: Conservation Needs Assessment</td><td></td><td></td></tr>
<tr><td colspan="3">CBW: Conservation of Biodiversity Workshop</td><td></td><td></td></tr>
<tr><td></td><td colspan="2">BIMS: Biodiversity Information Management System</td><td></td><td></td></tr>
<tr><td></td><td colspan="3">Gap Analysis</td><td></td></tr>
<tr><td></td><td colspan="3">REA: Rapid Ecological Assessment</td><td></td></tr>
<tr><td></td><td colspan="3">NCR: National Conservation Review</td><td></td></tr>
<tr><td></td><td></td><td></td><td>RBA: Rapid Biodiversity Assessment</td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td>RAP: Rapid Assessment Programme</td></tr>
<tr><td></td><td></td><td></td><td></td><td>ATBI: All-taxa Biodiversity Inventory</td></tr>
</table>

3.7 SUMMARY OF AVAILABLE INVENTORY TECHNIQUES

3.7.1 Gap Analysis

Gap Analysis, developed by US Fish and Wildlife Service and others, is essentially a coarse-filter approach to biodiversity conservation. It is used to identify gaps in the representation of biodiversity within reserves (ie. areas managed solely or primarily for the purpose of biodiversity conservation). Once identified, such gaps are filled through the creation of new reserves, changes in the designation of existing reserves, or changes in management practices in existing reserves. The goal is to ensure that all ecosystems and areas rich in species diversity are adequately represented in reserves. Gaps in the protection of biodiversity are identified by superimposing three digital layers in a Geographical Information System (GIS), namely maps of vegetation types, species distributions and land management use. A combination of all three layers can be used to identify individual species, species-rich areas and vegetation types that are either not represented at all or are under-represented in existing reserves. In practice, vegetation, common terrestrial vertebrate species, and endangered species are used as surrogates to represent overall biodiversity.

3.7.2 REA: Rapid Ecological Assessment

Rapid Ecological Assessment is a technique developed by The Nature Conservancy (TNC) as a tool to aid conservation planning in large, poorly-studied, or exceptionally biodiverse areas. The REA process consists of a series of increasingly refined analyses, with each level further defining sites of high conservation interest. The levels involved are satellite observation; airborne remote sensing; aerial reconnaissance; and field inventory. Analysis of satellite images is used to produce maps of ecoregions, land cover and priority areas; while integration with data from airborne sensors and aerial reconnaissance produces more detailed maps, extended to cover vegetation types and ecological communities. These are used to direct the cost-effective acquisition of biological and ecological data through stratified field sampling. Such data are used to support the conservation planning process and identify priority sites. Spatially-referenced information is managed by GIS, allowing easy data handling and generation of maps. Other conservation information is managed through manual files and a relational database called Biological and Conservation Data (BCD) developed by The Nature Conservancy.

3.7.3 Conservation Biodiversity Workshops

Conservation Biodiversity Workshops (CBWs) were developed by Conservation International (CI) as a means of setting conservation priorities in large geographic regions. The technique entails collating biological information - in particular maps prepared by CI's geographic information system, CISIG - and using it as a focus for discussion at a Workshop of field scientists who are the world's leading experts on a region's species and ecosystems. In this way the knowledge attained by biologists through decades of field work can be captured. Following this initial stage of the Workshop, the maps are used as catalysts to obtain a group consensus on biological priorities for conservation throughout the region. One vital output of the Workshop is a Final Workshop Map which summarises the information available, synthesising and integrating the data and opinions of the experts who attend. This provides a single coherent picture that decision makers can readily understand. Maps continue to play a key role even after the Workshop is over, since as easily interpreted

images reflecting a broad consensus among experts they can help governments, NGOs and funding agencies decide where to allocate their resources.

3.7.4 CNA: Conservation Needs Assessment

The Conservation Needs Assessment (CNA) was implemented for Papua New Guinea by the Biodiversity Support Program (a USAID-funded consortium of the World Wildlife Fund-US, The Nature Conservancy and the World Resources Institute). The process involved is outlined in the paragraph above on Conservation Biodiversity Workshops. Conservation International was responsible for preparing the maps for participants at the Workshop, and concerned itself primarily with biodiversity information. It is important to note that in addition to biologically-oriented project teams, several non-biological project teams were also appointed prior to the Workshop to examine conservation implementation. These were a social scientist's team, a legal team, an information management team and an NGO/landowner team. The CNA process is considered to be a starting point for participatory approaches to conservation and sustainable development, and takes account of social and political realities.

3.7.5 National Conservation Review (using Gradsect sampling)

The aim of the National Conservation Review (NCR) is to identify an optimal or minimum set of sites which is representative of the national biodiversity of Sri Lanka. This is achieved through the collection of data on species distributions and their subsequent analysis. Surveys are conducted to assess these distributions (see below). The sampling procedure involves the following steps: identification of sites, positioning of transects along environmental gradients, inventory of flora and fauna within plots. The NCR also has a hydrological and soil conservation component. These attributes of forest are measured concurrently by a separate survey team. An iterative complementarity procedure is being used to define a minimum set of sites necessary to conserve Sri Lanka's biodiversity. The biological survey technique employed was Gradient-directed transect (Gradsect) sampling. Transects were deliberately selected to traverse the steepest environmental gradients present in an area, while taking into account access routes. This technique is considered appropriate for rapidly assessing species diversity in natural forests, while minimising costs, since gradsects capture more biological information than randomly-placed transects of similar length.

3.7.6 BIMS: Biodiversity Information Management System

The Asian Bureau for Conservation has developed and distributes a software package called BIMS (formerly MASS = MacKinnon-Ali Software Systems) which can be used for monitoring the conservation status of species, wildlife habitat and protected areas on a national basis. The underlying principle is that the distribution and occurrence of species whose habitat requirements are known is predictable and can be mapped. MASS monitors the status of individual species by assessing the extensiveness, rate of loss and degree of protection afforded to their required habitats. The technique uses empirical modelling to estimate distribution and abundance patterns of species from sparse primary data, stored in a relational database. It includes estimates of the threats to the species being modelled. BIMS is based on a mapped habitat classification and can generate expected and confirmed species lists for any locality.

3.7.7 RAP: Guidelines for the Rapid Assessment of Biodiversity Priority Areas

The World Bank and the GEF are currently funding CSIRO and other Australian institutions to develop a series of Guidelines for Rapid Assessment of Biodiversity Priority Areas (RAP). These will adapt RAP tools employed in Australia for use in developing countries. The Guidelines are still under development. The basic principle is that priorities need to be set in conservation. The technique used will be to compile a suitable database containing maps of the spatial distribution of the biodiversity surrogate chosen, and then use it systematically to identify a network of areas that collectively represents that surrogate. A complementarity approach will be recommended, in which priority areas are added on the basis of the elements of biodiversity they contain which are different from those already covered. Application of CSIRO guidelines will enable assessment of the relative contribution of different areas to overall biodiversity protection. Conservation initiatives will then be focused on areas that make a high contribution.

3.7.8 ATBI: All Taxa Biodiversity Inventory

The aim of an All Taxa Biodiversity Inventory, developed by the University of Pennsylvania in conjunction with INBio (Costa Rica), is to make a thorough inventory or description of all the species present in a particular area, using highly trained taxonomic specialists recruited internationally and nationally. The rationale behind this approach is that species have to be used (ie. must have a utilitarian value to human societies) in order to be preserved, and have to be described and understood before appropriate uses can be found for them. The goals of ATBI are: to recognise and describe species and assign stable scientific binomial names (facilitating information exchange between researchers in different parts of the world); determine where at least some of the members of each taxon or species live and can be found; and, through accumulation of ecological and behavioural information, determine their role in the ecosystem.

3.7.9 RBA: Rapid Biodiversity Assessment

Rapid Biodiversity Assessment, developed by MacQuarie University (Australia) and others, is based on the premise that certain aspects of biological diversity can be quantified without knowing the scientific names of the species involved. Data are gathered on certain groups of organisms. Several groups, chosen as good 'predictor sets' or 'biodiversity surrogates' of biodiversity are needed at each location inventoried. The main characteristic of RBA is reduction of the formal taxonomic content in the classification and identification of organisms. There are two methods by which this can be achieved:

Ordinal RBA In this approach only those taxonomic levels needed to achieve the goals of the assessment in question are used. Ordinal RBA is frequently used in environmental monitoring. For example, if it is known from prior studies that the presence or absence of a particular family or genus indicates disturbance or pollution, it may only be necessary to resolve the species collected at a site to the level of family or genus to ascertain environmental quality.

Basic RBA The identification of large numbers of specimens obtained from a particular area during a biodiversity inventory may be problematic. An alternative to formal and correct species identification by expert taxonomists is the creation of locally functional schemes for classification and identification, using easily observable morphological criteria. For example,

butterflies might be distinguished on the basis of wing colour, pattern and size resulting in classifications such as 'Small, red with white spots.' The units of variety recorded by such a scheme may be called morphospecies, operational taxonomic units (OTUs) or recognisable taxonomic units (RTUs). Depending on whether operational procedures have been standardised and calibrated by conventional taxonomic measures, these units may or may not be less representative of natural biological variation than species *per se*. Biodiversity technicians trained by taxonomists can be used to separate specimens into RTUs. Studies show that if properly trained such personnel can be very effective.

3.7.10 RAP: Rapid Assessment Programme

Conservation International (CI) created the Rapid Assessment Program (RAP) in 1989 to fill the gaps in regional knowledge of the world's biodiversity 'hotspots'. These hotspots cover less than 4% of the Earth's surface, but are nonetheless inadequately inventoried. The RAP process assembles teams of world experts and host country scientists to conduct preliminary assessments of the biological value of poorly-known areas. RAP teams usually consist of experts in taxonomically well-known groups such as higher vertebrates (eg. birds and mammals) and vascular plants, so that ready identification of organisms to the species level is assured. The biological value of an area can be characterised by species richness, degree of species endemism (ie. percentage of species that are found nowhere else), the uniqueness of the ecosystem, and the magnitude of threat of extinction. A RAP is a precursor to prolonged scientific study. RAPs are undertaken by identifying potentially rich sites from satellite images / aerial reconnaissance, and then sending in ground teams to conduct field survey transects. Such field trips last from two to eight weeks, depending on the remoteness of the terrain. Reports of RAP activities are made available to the widest possible audience. Subsequent research and conservation recommendations and actions are the responsibility of local scientists and conservationists.

Table 3.2 Comparison of Biodiversity Inventory Techniques

TECHNIQUE	PURPOSE	DATA REQUIRED		SPECIAL FEATURES	EXAMPLES OF IMPLEMENTATION / AREA INVOLVED	SCALE	COST	TIME FRAME	SUITABILITY FOR LARGE GEOGRAPHIC AREAS	APPROPRIATENESS FOR NATIONAL SURVEY IN DEVELOPING COUNTRIES
		Taxonomic inventory at site level	GIS layers							
Gap Analysis	Identification of gaps in the representation of biodiversity in protected areas	May or may not involve surveys at certain sites identifying indicator groups to species level as 'ground truthing'	Vegetation and land use coverages; predicted or actual species distributions		Hawaiian forest birds Idaho	National / local	Medium	Medium	Medium	Low
REA Rapid Ecological Assessment	Identification of priority areas for conservation	Indicator groups to species level	Vegetation, land use, terrain, and geological coverages	Use of aerial survey and substantial ground-truthing	Jamaica (1,142,500 ha) New Mexico Small barrier islands off Virginia	National / local	High	Medium	Medium	Medium
CBW Conservation Biodiversity Workshops	Identification of priority areas for conservation	None	Vegetation, land use, topographical, and hydrological coverages; and distribution maps of key species	Use of workshop of national and international experts	Papua New Guinea Amazon basin	National / local	High	Short	High	High
CNA Conservation Needs Assessment	Identification of priority areas for conservation, taking account of social and political realities	None	Vegetation, land use, topographical, and hydrological coverages; and distribution maps of key species	Use of workshop of national and international experts; multidisciplinary approach	Papua New Guinea	National	High	Short	High	High
National Conservation Review (using Gradsect sampling)	Identification of an optimal (or minimum) set of sites for conservation, representative of national biodiversity	Indicator groups to species level	Not required	Involves extensive field survey work and low technological input	Forests of Sri Lanka	National	Low	Long	Medium	High
BIMS Biodiversity Information System	Monitoring the conservation status of species, wildlife habitat and protected areas	None	Not required	Uses a relational database to model species distributions and abundance using existing habitat maps and knowledge of species habitat requirements	China Thailand Bhutan	National	Low	Short	High	Medium

TECHNIQUE	PURPOSE	DATA REQUIRED		SPECIAL FEATURES	EXAMPLES OF IMPLEMENTATION / AREA INVOLVED	SCALE	COST	TIME FRAME	SUITABILITY FOR LARGE GEOGRAPHIC AREAS	APPROPRIATENESS FOR NATIONAL SURVEY IN DEVELOPING COUNTRIES
		Taxonomic inventory at site level	GIS layers							
CSIRO Guidelines for the Rapid Assessment of Biodiversity Priority Areas (RAP)	Identification of places within biomes or countries which should be managed for biodiversity protection	?	?	Guidelines currently under development; will probably use a combination of the other techniques in this table	None as yet	National / regional	Low?	Short?	High?	High?
ATBI All-taxa Biodiversity Inventory	Complete inventory of the species present in a particular area	Total inventory of all groups to species level	Not required	Requires considerable expert taxonomic input to cope with the discovery and description of new species	Guanacaste Conservation Area, Costa Rica (110,000 ha)	Local: site-specific	High	Long	Low	Low
RAP Rapid Assessment Programme	Preliminary assessment of the biological diversity of a poorly-known area	Preliminary inventory of indicator groups to species level	Not required	Extremely quick: requires small team of national and international experts	Columbia River Forest Reserve, Belize Alto Madidi, Bolivia (5,000,000 ha)	Local: site-specific	Low	Short	Low: but can be used at repeated sites in conjunction with other methods	Low
RBA Rapid Biodiversity Assessment	Assessment of the biological diversity of sites whilst minimising the formal taxonomic effort involved in classification and identification of organisms	Inventory of indicator groups to taxonomic levels higher than the species (ie. genus, family), **or** to operational or recognisable taxonomic units	Not required	Extremely quick: requires little taxonomic expertise. RBAs to data have concentrated on invertebrate indicator groups (although vertebrates and plants could be treated similarly)	Eastern Tasmania Ryan's Billabong and Mitta Mitta Creek	Local: site-specific	Low	Short	Low: but can be used at repeated sites in conjunction with other methods	Medium

Note: The four right-hand columns contain estimates of the comparative cost, speed and utility of the techniques as applied to a hypothetical standard area, measured in each case on a 3-point scale.

4. IDENTIFYING DIRECT USERS OF WILD BIOLOGICAL RESOURCES AND SOCIO-ECONOMIC IMPORTANCE OF USE

Summary

- *determine the appropriate spatial scales for study: for many purposes the local level will be most important, and regional and national level will be particularly based on village analysis;*
- *adopt realistic goals: aim to reduce ignorance to a level where appropriate action is possible;*
- *varieties of Rapid Rural Appraisal (RRA) can provide an overview of those socio-economic sectors most dependent on direct use of biological resources in subsistence and mixed economies at the village level, but should be combined with selected in-depth studies;*
- *economic analysis will be difficult in market economies because complex modelling is needed and input data are scarce;*
- *recent approaches combine RRA and Contingent Valuation Methods (CVM) to assess use preferences and value at subsistence level;*
- *regional and national data analysis are also necessary for a more complete understanding of trends in use and dependency.*

4.1 INTRODUCTION

4.1.1 To understand the socio-economic issues surrounding biodiversity conservation, use, and sustainability assessment it is necessary to establish:

- the critical spatial scale of use,
- which communities are using biodiversity directly at each scale, including subsistence and market economy use,
- how critical biodiversity use is for the welfare of each user.

4.1.2 Only when the users are identified is it possible to start setting priorities for conservation activities. In the majority of less-developed countries (LDCs), a high proportion of the population and an even higher proportion of those who make direct use of wild biological resources live in rural situations, usually in villages. For this reason, most studies regarding the economic and social importance of biodiversity in these countries should initially be directed at the village level. Regional and national pictures can then emerge by working up the hierarchy of spatial scales. To do this, the critical links between spatial scales need to be determined.

4.1.3 In more developed countries increased industrialisation and more intensive mechanised farming may mean that the regional or national level is a more appropriate scale for study. Key questions in both cases are: who are the users in villages, who are the users in individual industries in urban or rural areas?

4.1.4 It is also important to define the type of economic system in which biodiversity use takes place. Is it mainly a subsistence economy or is it a market driven economy? Most of the world's population lives in a mixed economy, existing not only by subsistence activities nor

relying entirely on the market for all goods. However, because there is a marked tendency to underestimate the significance of the subsistence economies, it is essential to ensure that this segment of the economy is well represented in any assessment.

4.1.5 Finally the extent of dependency on biodiversity for each user at the different levels needs to be determined. At the subsistence level, what is the proportion of 'wealth' or daily nutrition from biodiversity resources? Existing opportunities to find substitutes for particular biodiversity resources (food, fuel) should be identified.

4.1.6 Realistic expectations of such assessments are required because singular studies will never be able to collect enough quality information to build a truly complete picture. The aim is to reduce ignorance to a level at which useful and valid decisions can be made. Comprehensive data collection is hindered by the seasonality of natural resource, the occurrence of vital but intermittent use in emergencies (eg. famine), and time constraints. More detailed and focused surveys will be required to gather extensive data. A rapid and superficial analysis is likely to seriously under-estimate local level dependence on biodiversity for direct (including emergency) uses. A nationwide sample of rapid surveys, which may be statistically more representative, should be balanced by select case studies chosen either by ecological priority (eg. near fragile ecosystem) or because of socio-economic importance (dependent users represent large proportion of population). The major risk is to underestimate rural dependency on biodiversity resources because much of it is outside of the cash economy.

4.2 ASSESSING DIRECT USE AT THE VILLAGE LEVEL

4.2.1 The goal is to identify the use of and preference for biological resources for food sources, construction material, fuelwood, artisanal product and so forth. The following section first outlines the most important methods used for this type of assessment, both for subsistence and cash economy use. Because most of the world lives in a mixed system, distinctions between the two are often blurred.

4.2.2 The first step is to check existing data sources and literature for references and case studies on use of indigenous species. In many countries there is a wealth of information already collected and therefore, it is not always necessary to initiate ground surveys. Studies and projects in forestry, agroforestry, nutrition, traditional medicine, hunting and gathering, as well as agricultural extension and NGO reports can often supply base line data. Secondly, new studies will have to be commissioned to fill in the gaps. The use of and dependence on biodiversity resources at the local level must be aggregated where possible to regional and national levels because it is not possible to undertake nationwide detailed studies of all uses. Therefore, the selection of sites must be done with care that they are regionally representative of the socio-economic conditions of users and of the natural landscape and biodiversity present. The work should be undertaken by qualified and trained social scientists familiar with the region and participatory research methods. Special attention should be paid to the use of biological resources as wild foods and medicines.

4.2.3 Several methodologies are suggested for identifying users of biodiversity resources, the importance of these resources, and an assessment of threats and trends in biodiversity sustainability. These guidelines are descriptive rather than instructive and are not intended to provide step by step guidance on how to employ each of these complex methods. Indeed,

most of the techniques require professional training and substantial data. References for further technical information and illuminative case studies are provided in Annex 1. The method most often employed is Rapid Rural Appraisal (RRA).

4.2.4 RRA can help answer questions about the needs for biodiversity resources and the influences of their use at the local level. The term RRA refers to a wide range of techniques and methods; it is a structured and systematic activity designed to generate new insights about the range of opportunities and constraints of rural people. For this reason, RRA provides relevant and appropriate methods to assess the sustainability of biodiversity, as well as issues concerning the livelihoods of those dependent upon biodiversity resources. Advantages of RRA are that it is quick, cheap, insightful, relatively easy to learn, does not rely on existing baseline data, and involves a multi-disciplinary approach. Although designed to be employed by a team, RRA can be used by a single researcher. It is not a pre-set packaged methodology (Pretty and Scoones, 1989). It is suite of methods from which choices can be made to best suit any given situation. The use of various sources and various methods of data compilation promotes accuracy. RRA attempts to make biases and the level of ignorance explicit. RRA methods can be employed in a way that is sensitive to issues of gender and wealth distribution at the village level. Often a woman researcher is needed on the team to assess effectively women's access and use of biodiversity resources. The core techniques of RRA are outlined in Box 4.1.

4.3 VILLAGE LEVEL ANALYSIS OF SUBSISTENCE ECONOMIES

4.3.1 Use RRA techniques to identify which resources are being exploited, why, and any changes in quantity harvested. Specifically, an analytical game may be employed to discover preferences and uses of biodiversity resources for food sources, construction material, etc. Three examples are given in Box 4.2. An assessment should attempt to establish the availability of close substitutes, and the full socio-economic trade-offs of employing them. Two areas particularly worthy of examination are the use of biodiversity resources as wild foods and medicines.

Wild Foods

4.3.2 Direct interviews and RRA methods can be used to establish food uses of biodiversity, employing wild food categories and modes of acquisition given in Box 4.3. Wild foods can be a critical part of local livelihood strategies. They often provide a critical proportion of daily nutrition for the rural poor, generate cash for rural households, provide food in crisis situations, and add prestige for special events such as marriages. This important dependency on biodiversity should not be overlooked. The following five steps can be employed to assess their importance (adapted from Evans 1993):

- Short list the species used as wild foods by different ethnic groups in each ecological region of a country. This can be done using rank order of preference by a) season and b) use-value category of the food (see Box 4.3) Stratification by socioeconomic and socio-cultural groups, age, and gender is useful

- Enumerate frequencies and quantities of wild foods used by different groups

- Include a time frame to help indicate actual change in wild foods populations, their habitat, and relate this to locally perceived change

- Assess the actual and potential contribution of wild food for local income generation, and for local incentive to conserve wildlands

- Assess the actual and potential contribution of the most commonly used wild foods to local diet.

Box 4.1 Core RRA Techniques

The core techniques common to most RRAs are:

Secondary data review
Relevant published or unpublished data acquired by other studies and individuals are reviewed.

Direct observation
Direct observations of field objects, events, processes, relationships or people are recorded by the team.

Semi-structured interviews
Guided interviews are conducted for which only some of the questions are predetermined and new questions that arise during the interview are presented. Checklists can be used as reminders of topics that should be covered.

Analytic games
Simple games draw out the knowledge and preferences of the interviewees in order to produce a comparative ranking and to discover the criteria on which those choices have been made. It is very useful for identifying which families and individuals are most dependent on biodiversity resources and their preferences and seasonal needs. Seasonal calendars and pair-wise preference games are two analytical games often employed.

Stories and portraits
Short, colourful descriptions told by the interviewees which produce a 'snapshot' of information which is otherwise difficult to compile.

Diagrams
Simple schematic diagram constructed with the informant which presents information in a uncomplicated visual form and serves to dramatically simplify complex information.

Workshops
A common means of bringing people together, they can be useful to review and analyse compiled information.

Source: adapted from Pretty and Scoones (1989) and McCraken *et al.* (1988)

Box 4.2 Examples of RRA Analytical Games

RRA Analytical Games

Pairwise Choices
Informants may be asked to make pairwise choices between six different biodiversity resources of interest to both the interviewer and interviewee, such as six indigenous trees used for fuelwood. The interviewer then asks pair-by-pair which is preferable, together with why. In this way, a ranking of the most to least preferred is produced, along with all the criteria used. The process requires about one hour to complete.

Seasonal Calendars
Seasonal calendars are constructed together with the interviewee to represent all the major changes which occur within the year, and when and which biodiversity resources are exploited. The calendar can be constructed on the basis of individual interviews or group questions and discussion. There should be room on the calendar to include problem times, such as periods of drought, and times of opportunity, such as when new crops are grown. A few rounds of the calendar game can be done to cover areas of basic use of biological resources. For example, one game can be done for food, fuelwood, and building materials.

Advantage and Disadvantages of RRA games
A wider and more comprehensive variety of biodiversity uses will be discovered by means of RRA games than with interview or other techniques. Initial assessment would serve as a base line for various types of research. However the games are time-consuming and fewer interviewees can participate. Thus, the need to extrapolate becomes greater.

Source: adapted from Pretty and Scoones (1989)

Box 4.3 Wild Foods

Three Classifications of Wild Food

Hunger Foods
Used only when preferred foods are not available, often in crisis situation where starvation could occur. People do not readily admit to eating them, and only socially marginal groups sell them. Nonetheless, they are vital in times of crisis.

Staple Wild Foods
Served as common accompaniments to everyday meals. Their use varies with the seasons and ability to buy 'modern' food. Examples include leaves, fruits, berries, tubers, flowers, insects, reptiles, gums and resins, honey, fish, and game.

Luxury Wild Foods
Afforded by relatively rich people or for special occasions. They are usual scarce, which adds to their prestige and cost.

Modes of Acquisition
Extraction: collecting or hunting in the 'wild'.
Tended *in situ*, within the natural habitat.
Semi-domesticated: *ex-situ*, without a strong attempt to selectively improve their genotypes (eg. use of seeds, captured wildlife, fish, etc).

Source: adapted from Evans 1993

Medicinal Uses

4.3.3 Biodiversity may play a significant role in traditional medicines. In poor nations, at least 75% of all medical drugs are based on plants and animals (Principe, 1991). Furthermore, analyses of medicinal plants shows that the cultural role of these plants is central to how they are utilised and how their habitat is managed (Brown and Moran, 1993). Ascribing an economic value to medicinal plants can be based either on the current use values or the potential future use values ('option values'). For this type of assessment, a focus on current use is more useful. The valuation can focus on the replacement cost of 'traditional' medicine by purchased drugs, or focus on the value of the medicine in terms of its life-saving properties, using a value of a 'statistical life'. See Annex 1 (Bibliography) for references of these types of studies.

4.4 VILLAGE LEVEL ANALYSIS OF MARKET ECONOMIES

4.4.1 In market economies, economic analysis can help determine the importance of biological resources at the village, regional, and national level. At the local level, marginal analysis can help determine the dependency upon biological resources and the rates at which substitutes can be employed (eg. rubber being replaced by plastics at local factory). There are difficulties with these methods. First, trained economists are needed to undertake sophisticated modelling, and second, detailed data on values and quantities of biological resources are necessary but seldom available. Values are not easy to obtain because biological resources seldom have observable prices. Those that do have prices are often 'under priced' by the market because the market does not recognise the total value of resources. Other methods must therefore be employed.

4.4.2 Direct interviews

This approach may be used to investigate use of a key resource by a wide variety of users. For example to determine the changing patterns in charcoal and wood use in the Sudan, Pretty and Scoones (1989) report interviewing brick-makers, builders, carpenters, cheese-makers, bakers, farmers, displaced merchants, charcoal-makers and others. The advantages of direct interviews is that a wide variety of social sectors can be polled relatively quickly.

4.4.3 Survey local markets

The aim is to monitor change in produce available. Once a baseline is established, changes in price and availability can be monitored. For example. are exotic fruits flooding the market? While this method may be quick, it will exclude any change in subsistence activities.

4.4.4 Hypothetical Market Methods

These approaches can be used when resources do not have observable prices. Some of these methods require that individuals state their 'willingness to pay' (eg their price) in a hypothetical context. Other methods observe actual behaviour and infer valuations based on that behaviour. Box 4.4 outlines the different methods which might be used, and Box 4.5 highlights one methodology, the Contingent Valuation Method (CVM). One method

developed in response to the need to attach value to biodiversity resource use combines RRA and CVM techniques to determine subsistence use of resources by using pictures and games (Emerton, in prep. ESCOR/BDDEA field study). Once a list of most-used resources is established (eg. firewood, grazing areas, wild honey) the farmer is asked to name and price a consumer good he/she would like to acquire. This good, usually a bicycle or radio, is then added to the list of resources. Next, the farmer is asked to prioritise the resources by distributing 10-15 pebbles or matchsticks among the list of resources. The result is a cashless comparison between biological resources and consumer goods, which can be translated roughly into monetary terms *via* the priced consumer goods.

Box 4.4 Three Valuation Methods

Valuation methods
The following techniques are frequently used to estimate the value of natural resources. The application of these techniques to biodiversity is challenging and the interpretation of the data must be done with great care.

Replacement Cost Technique
This technique estimates the cost of replacing or restoring biodiversity loss. It measures the benefit assigned to the original asset, not the replacement. For example, the 'insurance' value of planting seven varieties of sesame *Sesamum indicum* might be inferred from the cost of crop failure insurance. The major difficulty lies in identifying close replacements for lost biodiversity.

Travel Cost Method
Expenditures on commodities that are substitutes or complements for the biodiversity good/service are employed to value changes in that biodiversity good. For example, the travel cost of visiting a park to observe wildlife may indicate the value of the biodiversity in the park. There are numerous problems with this method concerning aggregation and the relation between the number of trips and the price.

Hedonic Price Methods
This method estimates an implicit price for an environmental attribute, such as the real estate value of two identical houses, one near a park, the other near a chemical plant. Wage risk premiums also often used to value changes in morbidity and mortality arising from environmental hazards. However, these methods may not be suited to developing countries where land and labour markets are unlikely to function so as to capture such differences in value.

Source: adapted from Brown and Moran, 1993

4.4.5 Survey local industries

Assessment should also include individual industries which are based on locally produced natural resources such as rattan, rubber or indigenous wood. Priority for assessment can be given to the industries which either generate the most employment, export earnings, or infrastructure development. If relevant data are available, marginal analysis or input-output analysis (see below) can be undertaken. Otherwise, a crude analysis of the quantity of resources used per year and the potential of using substitutes should be carried out.

Box 4.5 Contingent Valuation Methods (CVMs)

Background to CVMs
The primary source of valuation data is observation of market prices and quantities exchanged. However, there is a range of techniques that may be employed to determine non-marketed and economic values of biodiversity and biodiversity resources. Economic models of consumer behaviour describe how individuals make purchases (or direct extraction of biodiversity good) according to their preferences and income constraints.

Willingness to pay (WTP) Surveys
WTP is a CVM method which uses surveys to ask people how much they are (hypothetically) willing to pay for a change in a given biodiversity resource. The typical survey begins by giving background information to respondents on the resource in question, then they are told about the change in the resource (eg. conservation or possibility of extinction). The answers are interpreted in the context of conventional economic theory.

Disadvantages
There are numerous problems with these methods, notably the numerous potential biases in any survey. It is a laborious process to construct the model, conduct surveys, and analyse the results of a CVM. Further, because CVM surveys do not measure preferences, they are not suitable for cost-benefit analysis (Hausman 1993).

4.5 ASSESSING DIRECT USE AT REGIONAL AND NATIONAL LEVELS

4.5.1 To understand the social and economic issues surrounding biodiversity sustainability at the regional and national level, it is necessary to establish which sectors of the economy are dependent upon biodiversity and biological resources. Important sectors of the economy include agriculture, fisheries, forestry, tourism, as well as natural resource based industries such as rubber, timber products, and rattan. Major steps are:

- identify major industries which draw resources from across regions and analyse their dependency on natural resources;
- extrapolate from case studies completed at the village level to regional level for major economic sectors and individual industries which draw depend upon local natural resources (eg agriculture, forestry, fishers, small scale furniture production, etc);
- identify major trends in land and water use change.

4.5.2 Input-Output and Marginal Analysis

Economic analysis such as input-output models and marginal analysis may be helpful to identify the extent to which industries are dependent upon biological resources, assuming data are available. Input-output models measure flows of resources into and out of a given industry and are useful to analyse linkages between areas of economic activity at the regional and national level. Marginal analysis can describe the possible rates of substitution for natural resources inputs of a given industry. To do this, the demand for the resource input, the price paid, the quantities available, and the possibilities of substitutes must be known. Data for these types of analysis should be available for some larger industries, but lack of data is likely to remain a problem in most industries.

4.5.3 Extrapolation

Extrapolation from the village to regional levels, as well from regional to national levels, should be based on statistically sound methods to prevent unnecessary biases. It is advised that extrapolation be based both on representation of ecological zones as well as socio-economic trends. Emphasis throughout any assessment of the status of biodiversity, and trends therein, must be placed at the local and village level because this is the scale at which ultimate causes of threat exert their effect 'on the ground', and it is at the same time the scale at which conservation and management measures are implemented or resisted, according to the attitudes of local residents.

4.5.4 Looking for Trends

In addition to identifying users of biodiversity resources, it is important to identify spatial and other variation in patterns of use, for example:

- region: are the people in region X more dependent than in region Y?
- socio-economic measures: are the poorest more dependent?
- economic sector: are cash croppers less dependent than subsistence farmers?
- gender: do women farmers use more biodiversity resources for daily use than their male counterparts?
- industry: are small natural resource based industries, such as rattan furniture making, dependent upon resources which come from another region? Is there interregional dependency?

5. ASSESSING SOCIO-ECONOMIC THREATS TO BIODIVERSITY

Summary

- *underlying or ultimate threats to biodiversity arise within the socio-economic and policy framework generated by human communities;*

- *issues of land tenure and access rights to biological resources are central to sustainable use, and it is unrealistic to expect individuals without solid tenure or access rights to manage resources wisely;*

- *RRA and other survey methods should be used to establish rights and the extent to which they apply in practice;*

- *growth and spread of human settlements often have adverse impacts on biodiversity; evaluation of this factor requires analysis of human demography and regional studies of factors driving growth and movement;*

- *the costs of conserving biodiversity are often borne locally while the benefits accrue at national or global levels; this is a powerful disincentive to sustainable use but challenging to correct;*

- *distortions in the economy, caused by government policies and misleading market prices, create the conditions which give people the incentive to misuse biological resources and expedite biodiversity loss.*

5.1 INTRODUCTION

5.1.1 Biodiversity losses above background rates can be attributed to human economic, cultural and social activities, and relate in particular to land tenure systems, the scale and growth of human population, and the direction of economic incentives. It is necessary to gain some understanding of the causal factors, which operate at the village, provincial, national and international systems level.

5.1.2 Environmental economists (eg. Pearce and Moran, 1994) are converging on a model involving 'economic failure' as the root cause of biodiversity loss. There are several kinds of economic failure; most fundamentally, there is disparity between the way costs and benefits are perceived by the individual or organisation and the way they affect society, nationally or globally. In other words, existing market systems fail to capture the true value of natural resources. An action of benefit to an individual (eg. direct dumping of pollutants in a river) may entail social costs elsewhere (reduced water quality downstream), but these *externalities* are not perceived by the individual and are thus ignored. Similarly, an action good for society (eg. strict protection of a block of woodland) may entail costs to individuals (loss of foraging rights) but give no perceived benefits. At another scale, preservation of a species-rich forest might have benefits to the global community, in terms of biodiversity maintenance, but without compensatory benefits there may be insufficient incentive to the country managing the forest.

5.1.3 The following taxonomy of economic failure can be proposed:

- *market failure*
  local, failure in free markets to take account of externalities, or to take benefits of biodiversity conservation into account;
  global, missing markets or global appropriation failure, where countries or communities external to those bearing the costs of conservation receive benefits with no costs;

- *intervention (or government) failure*
  failure of governments to intervene appropriately in markets, eg. by under-pricing water or subsidising deforestation.

5.1.4 The magnitude of the kinds of economic failure can be demonstrated only by putting in place a system of biodiversity resource valuation. According to Pearce and Moran (1994), the information available does not suggest that biodiversity conservation will never be the preferred option over land conversion, nor is it the case that biodiversity conservation will always be the preferred option; rather there are likely to be many cases where it will be able to compete with other uses of land provided that systems exist ensuring parity with alternative uses and the fair appropriation of global benefits. This latter in part underlies the emphasis put by the Convention on Biological Diversity (Article 21) on development of a financial mechanism allowing funds to flow from more developed to less developed countries in support of biodiversity conservation in the latter.

5.1.5 An assessment of the underlying causes of biodiversity loss should focus on the regional and national policies and trends, with some 'ground truthing' at the village level. It will not be possible to identify all threats to a nation's biodiversity. Therefore, it is suggested that an assessment begins with the ecosystems and species thought to be most threatened or those which are most depended upon by sectors of the economy.

5.1.6 The following material outlines methods to assess five main underlying threats to biodiversity: land tenure, population change, cost-benefit imbalances, cultural factors, and mis-directed economic incentives. The significance of these issues will vary from country to country, but it is recommended that an assessment consider all five aspects, because the influences of these factors may not be initially transparent and may differ from region to region.

5.2 LAND TENURE

5.2.1 Land tenure and the rights of access to natural resources are critical to sustainable use of biodiversity. It is unrealistic to expect an individual or community with no long-term tenure or legally-backed rights of access to manage resources in a sustainable manner (UNEP, 1993). The important consideration in analysing property rights is to assess the extent to which the current pattern precludes sustainable resource use or jeopardises the maintenance of essential ecological services. It is necessary to focus on the vulnerable members of society whose tenure rights are most often ill-defined. Women may also be of special concern in this part of the assessment as their traditional rights tend to erode more quickly than those of men. It must be noted that often 'on the ground' tenure situations are very different from those set out in title deeds and legislation. Therefore, it is imperative that in sensitive areas,

such as at forest boundaries, RRA techniques be used at the village level to establish the true situation of functioning tenure practices.

5.2.2 Common property can be either open access or restricted by some social sanction. Open access resources, from which no one can be excluded, tend to be over-exploited because even if an individual wanted to conserve parts of the resource for future use, another individual could still extract resources for personal gain. This is not to say that only privately owned property is desirable. On the contrary, well managed common property resources (CPR) are often extremely efficient mechanisms for promoting sustainable use. The choice of assessment method depends partially on the type of tenure system. The following outlines appropriate methods by tenure system. It will in general be necessary also to assess the institutional capacity of relevant government departments to enforce access laws and property rights. See Annex 1 (Bibliography) for references on land tenure, common property and open access resources.

5.2.3 Methods for assessing land tenure: private or state owned property

Undertake a systematic review of property rights laws by region. Use Rapid Rural Appraisal to check local application of property rights and resource exploitation of state owned land. Techniques might include interviews and games, with care to ensure that all sectors of the community are included in the assessment. Special regard should be given to assess trends in women's land tenure rights. Carry out formal interviews of those responsible for state owned land to assess trends in capacity to manage and maintain restrictions on access.

5.2.4 Methods for assessing land tenure: common property resources

Common Property Resources (CPRs) occur where there are limited but multiple members who are dependent on a given resource as a source of economic activity. The key fact is that the members are linked and interdependent so long as they continue to share a single CPR. The members may be herders on common pastures, fisherfolk using common streams or ports, irrigators relying on a common water source, etc. With effective CPRs, resources can be managed in a sustainable manner over time. Box 5.1 outlines seven characteristics of long-enduring CPRs. RRA techniques should be employed to assess any changes in these parameters. Deterioration may result in the CPR breaking down into inefficient or unsustainable resource use. A framework of complex variables is proposed for assessment rather than a model. The key aspect of CPRs is the definition of boundaries of the resource and/or the specification of individuals who can use the resource. Without these boundaries, 'outsiders' are permitted to exploit the resource and the resource becomes 'open access'.

5.3 REGIONAL AND NATIONAL POPULATION CHANGE

5.3.1 The effects of human settlements and activities are perhaps the most important factors in biodiversity planning. It has been shown that in some areas rapid population growth leads inevitably to increased degradation and over-exploitation of biodiversity. However, a few studies have shown that population growth can have positive socio-economic and technical effects which outpace threats to natural resource depletion (eg. Tiffen *et al.*, 1994). A complex set of causes interacts to affect both rates of population growth and increase (or decrease) in biodiversity and natural resource use. Communities of indigenous peoples,

minority ethnic groups, and others who are closely associated with biological resources, such as forest dwelling peoples, require particular attention.

Box 5.1 Characteristics of CPRs

The following seven characteristics of a healthy CPR should be assessed on a regular basis:

Clearly defined boundaries
Individuals or households who have rights to extract or use resources from the CPR must be clearly defined, as must the boundaries of the CPR itself

Congruence between appropriation and provision rules and local conditions
Appropriate rules restricting time, place, technology, and/or quantity of resources are related to local conditions and to rules providing labour, material, and/or money input to the CPR.

Collective-choice arrangements
Most individuals affected by the operational rules can participate in modifying the operational rules

Monitoring
Monitors, who actively audit CPR conditions, are accountable to the community. Monitors may be integrated into the CPR itself and difficult to identify.

Graduate sanctions
Members of the CPR who violate operational rules are likely to be given graduated sanctions, depending on the seriousness of the offense.

Conflict resolution
Members of the CPR have rapid access to low-cost local means to resolve conflicts among themselves or local officials

Minimum recognition of rights to organise
The rights to members to devise their own institutions are not challenged by external governmental authorities.

Source: adapted from Orstrom 1990.

5.3.2 Population movements are commonly analysed by study of the topology of rural-urban and rural-rural movements. This method is often not adequate because it does not make the distinction between temporary and long-term movements. For analysing the effect of population change on natural resource use, Tiffen *et al*. (1994) found it necessary to make the distinction between migration (change in location of entire family) and circulation (temporary movements for particular purpose, often by single members of a family).

Methods to monitor the relationship between population and biodiversity sustainability

5.3.3 **Analyse human population data**

Gather and analyse population data from national censuses, partial information from local governments, academic research, NGOs, etc. The principal disadvantage of this method is that this class of data, especially at the national level, is generally not adequately detailed to determine causal factors. The most important demographic factors will differ depending on the circumstances of individual countries. The following are likely to be among the key parameters (after UNEP, 1993):

- population density and distribution
- existing and projected growth rates
- age distribution
- gender distribution (related to migration)
- education level
- health
- relative proportion of urban/rural population
- size and pattern of human settlement
- population migration, including seasonal movements both historic and current.

In-depth regional studies

5.3.4 The intention here is to determine more precisely the impact of population growth on biodiversity. Factors such as availability of capital and security, knowledge of opportunities and technologies, economic incentives and access to jobs, land or markets should be considered as well as those given above. Tiffen *et al.* (1994) provides a model of this kind of detailed regional study.

5.4 COST-BENEFIT IMBALANCES

5.4.1 Benefits derived from conserving biodiversity may accrue directly or indirectly to the world as a whole; however, in many cases the costs are borne at the national and local level, with the heaviest burdens often sustained at the village level in rural areas. This has been proven to be a powerful and significant disincentive to sustainable biodiversity conservation (Wells, 1992).

5.4.2 These imbalances must be mitigated using site-specific and/or national strategies. Therefore, it is critical to assess and monitor the distributions of costs and benefits at both the local and national levels. Where significant imbalances are found, priority consideration should be given to correct the imbalance through efforts such as local income generation schemes, extractive reserves, and integrated conservation-development projects.

Methods to Assess Distribution of Costs and Benefits

5.4.3 **Local level**

At this level, cost and benefit categories as given in Box 5.2 can serve as a framework. Qualitative and quantitative assessments are required, and RRA techniques may be best employed to make estimates.

5.4.4 **National level**

At the national level, a general comparison can be made using the format suggested in Box 5.3. Data can be compiled from national ministries (eg. of tourism), relevant aid flows, extrapolating from valuation case studies, etc. See the UNEP *Guidelines* for detailed guidance on compiling appropriate data.

Box 5.2 Table for field assessment of Relative Significance of Costs and Benefits of Conservation.

Relative significance of protected areas/conservation projects benefits and costs at on three spatial scales. Complete framework by indicating on a scale (eg. 1-10) where the benefits/costs have the potential to be most significant.

	SPATIAL SCALE		
	LOCAL	NATIONAL	GLOBAL
Benefits			
consumptive	-	-	-
recreation/tourism	-	-	-
non-consumptive benefits	-	-	-
ecological processes	-	-	-
education/research	-	-	-
biodiversity benefits	-	-	-
Costs			
direct	-	-	-
indirect	-	-	-
opportunity costs	-	-	-

Source: adapted from Wells 1992

Box 5.3 Comparison of Costs and Benefits of Conservation at the Local, National and Global Level.

Comparison of protected areas/conservation projects benefits and costs at on three spatial scales. Complete framework either by indicating on a scale (eg. 1-10) where the benefits/costs have the potential to be the most significant or with compiled economic estimates.

Potentially most significant benefits		Potentially most significant costs
	LOCAL SCALE	
Consumptive benefits Recreation/Tourism Future values		Indirect costs Opportunity costs
	REGIONAL/NATIONAL SCALE	
Recreation/Tourism Watershed values Future values		Direct costs Opportunity costs
	TRANSNATIONAL/GLOBAL SCALE	
Biological diversity Non-consumptive benefits Ecological processes Education and research Future values		(Costs tend to be minimal)

Source: adapted from Wells 1992

5.5 CULTURAL FACTORS

5.5.1 Cultural factors can play a significant role in the use and conservation of biodiversity. For example, sacred groves may be preserved, the killing of certain wild animals may be constrained, or the density of cattle grazing may be controlled by long-established customs. As with effective CPRs, cultural traditions risk deterioration, resulting in the break down of customary management of resources. The pressures on traditions need to be assessed and monitored. Most of these factors cannot be quantified; therefore the most suitable methods for assessing them are RRA techniques such as diagrams, games, and interviews of local informants.

5.5.2 Cultural factors are very time-consuming to assess. Furthermore, they are locale specific and difficult to extrapolate to any meaningful generalisations. It is best to examine secondary data sources such as PhD theses and NGO reports on specific communities before launching cultural studies.

5.6 MIS-DIRECTED INCENTIVES

5.6.1 Economic incentives help determine the behaviour of individuals, companies, and governments. One of the most important factors influencing the use of natural resources is the pattern of economic incentives, which can either encourage or discourage behaviour leading to conservation of biological diversity. There are many ways in which the government's policies can influence the use of natural resources and habitats. For example, policies on trade and taxation may be designed for other purposes, but they may impact the decisions people make about resource use. The main sources of mis-directed incentives are 'market failures' and 'policy failures'. Market failure refers to the fact that markets do not fully reflect the value of biodiversity. For example, the price of timber does not reflect the cost of the lost habitat for forest animal species. The second refers to the policies which provide incentives for activities which result in biodiversity loss. The two types of failures are often interwoven and compounding. Table 5.1 outlines different types of economic policies and their potential environmental impacts.

5.6.2 Policy analysis is required to 'disentangle' the various linkages between policies and the lack of prices for environmental goods and services. First, models must be designed so we can understand the web of linkages, between say lower interest rates and extension of grazing lands into a savanna landscape.

5.6.3 Macro-economic analysis and econometric modelling can also be useful to identify incentives which provoke biodiversity loss. See Brown and Pearce, 1994, for examples of studies which identify policy failures leading to tropical deforestation. Both policy analysis and economic modelling require extensive data and experienced social scientists to undertake the analysis. See Barbier, Burgess, and Folke (1994), and Panayotou (1993) for case studies.

Table 5.1 Economic policies and their potential environmental impacts.

MACRO	FISCAL	GOVERNMENT EXPENDITURE	Publicly funded agencies can protect biologically unique areas; public infrastructure (roads and dams) may encourage land uses that degrade fragile areas.
		TAX/SUBSIDY	Multi-sector instruments can alter general demand conditions and thus use of resources; eg. income tax breaks may encourage speculation in land and/or unnecessary conversion of natural areas; "polluter pays" taxes and user fees can reduce waste and air/water pollution.
	MONETARY		Tied-credit analogous to subsidies; credit rationing and interest rate hikes may reduce demand, but can also discourage conservation investment.
	INTER-NATIONAL	EXCHANGE RATE	Devaluation increases prices of imported inputs (eg. pesticides, logging equipment), while increasing profitability of exports (eg. crops and timber); environmental impacts will depend on the nature of the resource and product affected.
		TRADE	Import/export taxes and quotas have effects similar to devaluation but on selected commodities only; may alter relative returns to environmentally destructive versus benign products.
		CAPITAL CONTROLS	When used to prop up over-valued currency, similar to revaluation of exchange rate.
SECTORAL		PRICE CONTROLS	May stimulate or retard environmentally damaging production; depends on nature of resource and products affected.
		TAXES/ SUBSIDIES	Usually indirect impact via changes in demand, but may alter choice of inputs/outputs; eg. incentive subsidies to livestock production may promote deforestation; fertilizer subsidies may retard adoption of soil conservation; pesticide subsidies may increase negative health effects of agrochemical run off, etc.

Source: from Bishop *et al.*, (1991).

6. CONCLUSIONS AND IMPLICATIONS FOR FUNDING

Summary

- *current human use of biodiversity is unsustainable in the long-term, but it remains difficult to predict the socio-economic impact of this;*

- *research into ecosystem functioning, coupled with active management of biological resources, needs to be expanded;*

- *it will generally be necessary to correct cost/benefit imbalances in order that local communities are enabled or persuaded to manage resources more sustainably;*

- *long term stable funding of conservation efforts is required to meet recurrent costs and to ensure long term goals are met.*

6.1 INTRODUCTION

6.1.1 The preceding parts of this report have outlined methods for assessing the status of biodiversity and the impacts of human activity on it. They have also outlined strategies for attempting to ensure that human use of biodiversity is sustainable in the long term. This chapter draws together in brief some of the major points and makes some observations regarding implications for funding of biodiversity-related activities in Less Developed Countries.

6.1.2 Human activities are undoubtedly leading to a global decrease in biological diversity. Some of this decrease, most notably that associated with the extinction of species, is permanent and irreversible. In this sense at least, current use of biodiversity is not sustainable in the long-term.

6.1.3 It remains difficult to predict what the socio-economic impact of the unsustainable use of biodiversity will be, particularly in the long-term. However some of it, for example that associated with large-scale deforestation or major overexploitation of many marine fish stocks, is likely to be grave.

6.1.4 The major reason for the unsustainable use of biodiversity is, simply, that short-term, immediate economic benefits accrue to individuals who exploit biodiversity, while the costs of such exploitation are usually borne more generally (by society at large) or are deferred into the future. It will therefore generally pay any individual to exploit resources to the maximum. The corollary of this is that any attempt to conserve biodiversity or ensure that its use is sustainable (which will normally entail some lowering of the rate or intensity of exploitation) will be perceived as a cost by those involved in the exploitation, both in terms of forgone benefits and actual costs of conservation.

6.2 IMPLICATIONS FOR ACTION

6.2.1 A major implication of this is that actions to maintain biodiversity cannot be planned efficiently until local and national interests, which very often conflict, can be reconciled at the appropriate scale.

6.2.2 Our understanding of biodiversity and, in particular, the operation of large-scale ecological processes, is still very imperfect. A great deal of theoretical and practical work still needs to be carried out, both by academic institutions and by agencies actively involved in management, policy and planning. Both types of institution are often seriously under-resourced in many Less Developed Countries (and, increasingly, elsewhere). There is a need for major technical and financial investment in these areas. Most LDCs are not currently in a position to provide this investment unaided.

6.2.3 Because resources are limited, it is important that priorities are set, both for areas of research and for projects to be implemented on the ground. A particularly important aspect of this is the use of **Cost-benefit analysis**. Costs need to be balanced with effectiveness in order to maximise the benefits obtained from the funds available. Measuring 'effectiveness' is very difficult as there is a degree of uncertainty surrounding many aspects of biodiversity. However, there are some indicators of importance, cost, and feasibility of intervention, and degree of threat. *To be cost-effective, interventions will need to focus on the feasibility of the project, the importance of the outcomes (eg. number of species 'saved'), the least cost measures, and where the threats are containable and ideally reversible.* This method requires clear measures of total costs of conservation, indicators of significance of the biodiversity in question, and the an assessments of the degree of threat. For an example of estimating costs of conservation activities, see IIED's economic analysis of the Costa Rican National Biodiversity Institute (Aylward *et al.*, 1993).

Sustainability of funding

6.2.4 Often, the correction of government failure, market failure and reduction of population pressure may not be sufficient to conserve a nation's biodiversity. In many cases, the opportunity cost of conservation is very high, especially when the short term pressures of economic and social development may call for expansion of certain activities to meet cash and employment shortages. Often governments will not have sufficient funds to commit over the necessary long periods of time required for successful conservation. Therefore, the presence of multi- and bi-lateral aid is necessary to help overcome national budget constraints. This was recognized internationally by the Convention on Biodiversity which was adopted by over 150 nations. The Convention recognizes the implicit deal that northern countries help poorer nations conserve some of their species.

6.2.5 Conservation is traditionally plagued by a lack of long-term investments, financially stable institutions and recognition as a national priority. Long-term funding, regardless of its origins, is necessary to help promote change in these areas by permitting financial security in a way that builds local institutional capacity and engenders long-term community participation.

6.2.6 Some projects will generate income, but rarely will they secure sufficient funds to cover all recurrent costs. The nature of most donor funding is short-term, usually less than seven years. Many conservation activities, however, require sustained funding of recurrent costs to secure a lasting impact. The institutions involved, as well as activities themselves, need assurance of future funding. Recurrent costs refer to any expense incurred on an annual basis to maintain the project, such as salaries to park wardens and maintenance of vehicles. In cases where donors do provide further financing for projects, detrimental interruptions in funding flows between separate project cycles are common. *Long-term financial commitment*

from the national government and where appropriate from donor nations and organizations is necessary for programme stability, long range planning, training and recruitment of personnel, and overall impact of a programme. At the same time, however, entitlement should not be created; a system of monitoring and evaluation must be integrated so that funding can be terminated if the objectives of the project are frustrated.

6.2.7 The need for financing to meet these needs arise because:

- revenue generating activity (and potential) from ecologically sound management of these resources is usually very limited;
- protection of globally important biodiversity lacks priority as a national development activity, so that once international funding ends, national funding is usually lacking;
- when surpluses are generated from ecotourism or other commercial, ecologically sound, ventures, they are captured for general national revenue, leaving capital replacement and maintenance capacities of the area impoverished;
- conservation and administration staff are too few, too poorly paid, and sometimes weakly motivated; they need job security, training and steady pay;
- most conservation sites are remote from urban centres, far away from where the cash economy and government administration is strongest.

Box 6.1 Hurdles to Long-term Conservation of Kenya's Wild Biodiversity

Kenya is world famous for its number and variety of rare, endangered, and endemic animal and plant species. Tourism is well developed and in large measure based on wildlife and natural landscapes. Revenue from tourism is Kenya's number one earner of foreign currency. However, the parastatal organization which is responsible for the wildlife and game parks, Kenya Wildlife Service (KWS), is far from being self-sustaining in financial terms. Furthermore, costs at local level often outweigh benefits reaped from tourism: elephants damage crops, crocodiles can sometimes kill people, and large game parks prevent pastoralists from grazing cattle on what were once tribal lands. Tourist revenues do not meet all financial requirements, and the national opportunity costs of conserving large habitats for endangered species are very large. It thus appears that donor funds will be required over the long term to meet recurrent costs of conservation.

Annual Figures for Kenya Wildlife Service:

US $ 68 million	budget for wildlife conservation
US $ 14 million	revenue from national park entrance fees
US $ 3.4 million	Government of Kenya (raised from taxes on residents and tourists)
US $ 40 million	annual funds received from multi- and bi-lateral aid and NGOs
US $ 6-10 million	shortfall

Source: Bradley-Martin and Lockwood, 1994)

Methods to assess sustainability of funding

6.2. Complete review of all funding for conservation projects, including projects funded nationally, internationally, and with bi-lateral funds, to answer the following questions:

- What is the percentage of projects with fewer than seven years of guaranteed funding? ...Less than five years? Do a majority of these projects include contingency plans for future funds?

- Which areas have the highest recurring costs? What are the mechanisms in place to meet these recurring costs in five, seven and ten years?

- Are there any long-term funding mechanisms being developed for the most critical areas?

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ANNEX 1

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ANNEX 2

FURTHER DETAILS OF BIODIVERSITY ASSESSMENT TECHNIQUES

This section provides expanded discussion of the survey and inventory approaches introduced in chapter 3 above. Citation of a key reference will be found at the start of the description of each method, and each closes with a brief appraisal of the features of the method and its suitability for different purposes.

GAP ANALYSIS (US Fish and Wildlife Service and others)

Source: Scott, J.M., *et al.*, 1993.

Brief summary of technique
Gap Analysis is essentially a coarse-filter approach to biodiversity conservation. It is used to identify gaps in the representation of biodiversity within areas managed solely or primarily for the purpose of biodiversity conservation (referred to below as reserves). Once identified, such gaps are filled through the creation of new reserves, changes in the designation of existing reserves, or changes in management practices in existing reserves. The goal is to ensure that all ecosystems and areas rich in species diversity are adequately represented in reserves.

Gaps in the protection of biodiversity are identified by superimposing three digital layers in a Geographical Information System (GIS), namely maps of vegetation types, species distributions and land management. A combination of all three layers can be used to identify individual species, species-rich areas and vegetation types that are either not represented at all or under-represented in existing reserves. In effect, vegetation, common terrestrial vertebrate species, and endangered species are used as surrogates to represent overall biodiversity.

Data needed

1 Maps of existing vegetation types, which are prepared from satellite imagery and other sources. The smallest unit mapped is usually 100 ha, because the overall process covers entire states or regions. Vegetation maps are checked through ground-truthing and examination of aerial photographs. Landsat Thematic Mapper digital imagery is now the standard source for Gap Analysis vegetation maps.

2 Predicted species distribution maps. These are based on existing range maps and other distributional data, extrapolated to include potential species ranges using data on known habitat preferences. Maps of a particular group or groups of species of political or biological interest can be synthesised from maps of individual species distribution. Gap Analysis normally uses vertebrate and butterfly species (and/or other taxa, such as particular groups of vascular plants) as indicators of overall biodiversity.

3 Land ownership and management status maps.

Assessment of likely availability of data
Vertebrates (particularly birds, followed by mammals) are the best-studied groups of animals. If a national data set for any taxonomic group exists, it is most likely to be for birds.

Costs involved
A GIS-supported Gap Analysis requires technical infrastructure, a great amount of baseline information, and highly-trained personnel. It is likely to be an expensive undertaking. Projects identified so far have been carried out mainly in developed countries: eg. the United States and Australia.

Human resources involved/required
A high level of technical competence is necessary to interpret satellite images, prepare maps, and manipulate the complex GIS data layers involved.

Data generated
Data generated by the Gap Analysis process include vegetation maps, maps of species' actual and potential distribution, and prioritisation of protected areas needs.

Time frame
No indication of the time required from satellite image acquisition to publication of Gap Analysis results is available.

Examples of implementation
Scott *et al.* (1986) conducted a Gap Analysis on endangered forest birds in Hawaii. Gap Analysis is now also being used on a state by state basis in the USA - results and recommendations of one for Idaho were under review in 1993.

Points for and against
For
- Gap Analysis provides a quick and efficient assessment of the distribution of vegetation and associated species, and can be used to generate recommendations for the conservation of biodiversity at short notice in response to rapid rates of habitat loss.
- The data layers generated and the GIS framework in which they are stored can be used as the basis for monitoring and evaluating changes in biodiversity at both fine and coarse levels.
- Data generated during the Gap Analysis exercise can be combined with other geographic datasets (if available) such as road networks, urban development etc.
- Many different questions in conservation biology and land-use planning can be addressed by Gap Analysis data, including potential impacts of human-induced changes.

Against
- Mapping units have a minimum size, which may result in the omission of significant but small patches of habitat, for example meadows and wetlands in a predominantly forest matrix.
- Vegetation maps often fail to distinguish between different successional (seral) or age stages in the plant community, which may result in the under-representation of a particular stage of a particular community. For example, they can identify large areas of unfragmented forest, but not whether the habitat is regrowth following a clear cutting or a forest fire, or 'old-growth' forest.
- Vegetation classes used in mapping must be distinguishable in remotely-sensed images and identifiable in large to medium-scale aerial photographs.
- Vegetation classes used must be compatible with those used to describe animal habitat preferences.
- Gap Analyses in the United States have shown about 70% accuracy in the prediction of species present in a given area. The presence of species of particular importance, such as rare or threatened ones, requires confirmation prior to site-specific management activity.
- Gap Analyses tend to be focused on national or regional reserve systems. In developing countries, many highly biodiverse regions will lie outside the protected areas network, and alternative strategies to the gazetting of new reserves may be required.
- Predicting species distributions on the basis of habitat types may ignore highly influential additional factors. For example anthropogenic factors (eg. pollution, hunting, disturbance) may greatly modify actual species distributions.
- For some groups, eg. reptiles, species distributions predicted on the basis of vegetation types may show poor correlation with actual distributions unless climatic variables are included as data layers.
- Predicting distributions of aquatic (riparian and wetland) species generally requires the use of a separate data layer representing hydrological features.
- Gap Analysis predicts the presence or absence of a species, but does not indicate whether it is rare or common at a particular site. Field work is necessary to determine the abundance of a species at a given location.
- The choice of indicator species groups may greatly affect the results of Gap Analysis. In addition, the empirical relationship between biodiversity in vertebrate species and other groups of organisms (eg. fungi, invertebrates, ferns, higher plants) has not yet been established.

- Gap Analysis requires a relatively high level of technical expertise (in GIS, satellite image interpretation etc).
- Gap Analysis is not a substitute for field investigation. The establishment of new reserves or management changes to existing ones should only be attempted after careful on-the-ground studies.

Appraisal
Gap Analysis can be a useful tool for identifying areas worthy of further investigation for biological significance and conservation needs. Gap Analysis should be viewed as complementary to conserving individual threatened species. It potentially permits the identification of areas of high biodiversity which are most in need of additional protection. It is probably most suitable for relatively developed countries with a high degree of technical infrastructure and a well-established existing reserve system.

RAPID ECOLOGICAL ASSESSMENT (REA): The Nature Conservancy

Source: Grossman, D.H. *et al.*, 1992

Brief summary of technique
Rapid Ecological Assessment (REA) is a technique developed by The Nature Conservancy (TNC) as a tool to aid conservation planning in areas that are large, poorly-studied, or exceptionally biodiverse. The REA process consists of a series of increasingly refined analyses, with each level further defining sites of high conservation interest. The levels involved are satellite observation; airborne remote sensing; aerial reconnaissance; and field inventory. Analysis of satellite images is used to produce maps of ecoregions, land cover and priority areas; while integration with data from airborne sensors and aerial reconnaissance produces more detailed maps, extended to cover vegetation types and ecological communities. These are used to direct the cost-effective acquisition of biological and ecological data through stratified field sampling. Such data is used to support the conservation planning process and identify priority sites.

Spatially-referenced information is managed by Geographic Information System (GIS), allowing easy data handling and generation of maps. Other conservation information is managed through manual files and a relational database called Biological and Conservation Data (BCD) developed by The Nature Conservancy.

Data needed

1. Maps, prepared from satellite data with aerial reconnaissance input and some 'ground-truthing'. The primary data need is for a vegetation map, but maps of the physical and social components of the landscape are necessary to identify threats. In a recent REA of Jamaica, Landsat Thematic Mapper (TM) data were acquired and processed; digital terrain data were obtained from existing GIS datasets and used to generate slope, aspect and altitudinal classes, and an existing 1:250,000-scale geology map was digitised and coded by TNC into GIS format.

2. Site-specific inventories of species present, conducted through field sampling at sites identified during initial analyses. Although not stated in the Jamaican methodology, it is likely that certain taxonomic groups are concentrated on. Suggested taxa are birds, mammals, butterflies and vascular plants.

Assessment of likely availability of data
The availability of satellite maps of vegetation and the physical and social components of the landscape is likely to vary by country. Field survey of specific sites is relatively straightforward, but it might prove difficult to access remote areas.

Costs involved
No indication of costs is available. The preparation of vegetation maps from satellite data is presumably a costly exercise, and requires highly-trained personnel.

Human resources involved/required
A high level of technical competence is necessary to manipulate the complex GIS data layers involved, and to interpret satellite data and images. Field surveys will not require either very many or well-qualified personnel.

Data generated
Phase 1 of the Jamaican REA produced an updated classification system of the vegetation types of the island, together with digital and hard copy vegetation maps, and digital and hard copy Landsat TM image data. Field surveys will provide site-specific inventories of key 'indicator' groups of species. These will be used to identify priority sites and conservation actions.

Time frame
A recent REA of Jamaica completed the field work for phase 1, an island-wide survey of the natural communities and modified vegetation types of the entire country, in six months. Jamaica however is relatively small in area (c. 11,425 km^2). In addition many of the required GIS data sets and maps already existed in a national database, the Jamaica Geographic Information System (JAMGIS), developed from 1982 onwards by the Rural and Physical Planning Unit (RPPU).

Examples of implementation
The Nature Conservancy has used REA on small barrier islands off Virginia, and to support conservation planning and inventory in Jamaica (Grossman *et al.* 1992), Mato Grosso (Brazil), South Carolina, Georgia and New Mexico (USA), and Venezuela.

Points for and against
The points for and against associated with the mapping component of the Gap Analyses technique also apply here. In addition the following points should be considered:

For

- REA involves substantial data acquisition from field surveys to 'ground truth' the impressions obtained from map preparation and analysis.
- REA is not restricted in scope to a protected areas network.

Against

- REA is not a particularly rapid technique, in spite of the name. Phase 1 of an area equivalent to Jamaica may take considerably longer than 6 months if existing GIS datasets are not available.

Appraisal
In effect, REA uses the same GIS datasets as a Gap Analysis, and then supports the analysis with subsequent ground-truthing. It is most appropriate for small countries (or defined regions of large countries) without comprehensive protected areas networks. It can be used to predict where high levels of biodiversity in need of protection exist.

CONSERVATION BIODIVERSITY WORKSHOPS: Conservation International

Source: Tangley, L. 1992.

Brief summary of technique
Conservation Biodiversity Workshops (CBWs) were developed by Conservation International as a means of setting conservation priorities in large geographic regions. The technique entails collating biological information, in particular, maps prepared by CI's geographic information system (CISIG), and using it as a focus for discussion at a Workshop of field scientists who are the world's leading experts on a region's species and ecosystems. In this way the knowledge attained by biologists through decades of field work can be captured. Following this initial stage of the Workshop, the maps are used as catalysts to obtain a group consensus on biological priorities for conservation throughout the region. One key output of the Workshop is a Final Workshop Map which summarises the information available, synthesising and integrating the data and opinions of the experts who attend. This provides a single coherent picture that decision makers can readily understand. Maps

continue to play a key role even after the Workshop is over because - as easily interpreted images reflecting a broad consensus among experts - they can help governments, NGOs and funding agencies decide where to allocate resources.

Data needed

1 GIS data layers including topography, hydrography, vegetation type, political boundaries, management categories (including protected areas and timber logging concessions), roads and population centres. The CBW process does not generate new data layers; rather it harmonises existing ones obtained from other institutions and government departments, by formatting them to a standard scale (eg. 1:1 million or 1:3 million) and projection.

2 Basic species distribution maps, representative of 'keystone' groups. These can be obtained from published sources, or through the distribution of blank maps to acknowledged experts, who are asked to draw their impressions of species' ranges. These data are then digitised for consistency and to allow their superimposition on other data layers. Such maps may be the result of individual contributions, but more often experts in a particular discipline are appointed to a 'project team' which is asked to submit a composite map providing a summary of their individual opinions.

Assessment of likely availability of data

GIS data layers are likely to exist for all countries, but their availability may be a matter of political sensitivity in some areas. Experts able to contribute advice and impressions of species ranges are probably available for most countries.

Costs involved

A CBW is an expensive process, requiring $US 100-500,000 (Silvieri, pers. comm.).

Human resources involved/required

The preparation of GIS data layers and maps requires GIS and computing expertise. The organisation of a CBW requires considerable input from a combination of international and national experts. The actual Workshop itself is a partnership between CI, government departments and (where available) NGOs. Up to 200 representatives from up to 50 institutions may attend.

Data generated

The CBW process generates a number of useful products, including compatible GIS coverage of the entire country (or region); refined maps of many species' distributions; a Final Workshop Map delimiting priority areas for conservation; and a database of the biological data gathered.

Time frame

The Workshop itself may only take 10 days to 2 weeks, but the process of preparing the maps and collecting biological data, together with training of host nationals in GIS techniques, and organising the Workshop and its constituent working groups may take 1-2 years.

Examples of implementation

CI organised a CBW for the Amazon basin in Manaus, Brazil in January 1990. The Final Workshop Map produced has been used by several Amazonian countries to guide conservation policy decisions. The second CBW was held in Madang, Papua New Guinea (PNG) in April 1992. During this CBW process, a number of working groups were organised on a thematic basis (eg. 5 faunal groups, 2 botanical, 1 socio-economic etc). Team leaders were appointed for each thematic group, responsible for collecting data from their constituent members. Further CBWs are planned for the Atlantic Forest region of Brazil and the Central African Region.

Points for and against

For

- By using a consultative, workshop approach, a CBW produces a broad consensus of expert opinion on conservation priorities. This can be used to wield more influence on government opinion than if a narrow, sectoral approach was used.
- Provides a visual synthesis of nationally important areas for biodiversity conservation in the form of a Final Workshop Map.
- The process is relatively fast.
- A CBW entails the technology transfer of databases and computers to the host country.
- Uses existing maps and reformats them into compatible GIS coverages.

Against

- Requires the availability of substantial data sets (particularly GIS data layers).
- A CBW is really only the first stage in the setting of national or regional biodiversity conservation priorities. It identifies areas in which field surveys/conservation measures may be necessary. Their implementation is an entirely separate process.

Appraisal

CBWs effectively summarise the existing biological knowledge of a region or country. They are most appropriate for setting investigation priorities in large, relatively unknown areas. A subsequent phase is to despatch RAP teams to unknown areas thought to contain high biodiversity (see below for a description of RAP).

CONSERVATION NEEDS ASSESSMENT: Biodiversity Support Program

Sources: Alcorn, J.B. (ed.) 1993. Beehler, B.M. (ed.) 1993.

Brief summary of technique

The Conservation Needs Assessment (CNA) was implemented for Papua New Guinea by the Biodiversity Support Program (a USAID-funded consortium of the World Wildlife Fund, The Nature Conservancy and the World Resources Institute). The process involved is outlined in the section above on Conservation Biodiversity Workshops. Conservation International was responsible for preparing the maps for participants at the Workshop, and concerned itself primarily with biodiversity information. It is important to note that in addition to biologically-oriented project teams, several non-biological project teams were also appointed prior to the Workshop to examine conservation implementation. These were a social scientist's team, a legal team, an information management team and an NGO/landowner team. The CNA process is considered to be a starting point for participatory approaches to conservation and sustainable development, and takes account of social and political realities.

Data needed

1 'Base Maps' prepared at the same scale and on the same projection of a number of factors affecting biodiversity, ie. political boundaries; coastlines; hydrogeographic features; roads; topography; vegetation type and cover; population centres; protected areas and timber rights purchases.

2 Biological maps of species distributions, which are prepared on the base maps by 'project teams' of scientists with expertise in a particular area or taxonomic group. These maps are debated and refined at the Workshop.

Assessment of likely availability of data

GIS data layers are likely to exist for all countries, but their availability may be a matter of political sensitivity in some areas. Experts able to contribute advice and impressions of species ranges are probably available for most countries.

Costs involved
No indication of the costs of the exercise are currently available, but it is obviously an expensive process.

Human resources involved/required
A CNA coordinates a multi-disciplinary team of international and national experts. Preparation of base maps requires GIS expertise.

Data generated
The CNA process generates the same kinds of product as the CBW, namely compatible GIS coverage of the entire country (or region); refined maps of many species' distributions; a Final Workshop Map delimiting priority areas for conservation; and a database of biological data gathered during the whole exercise. In addition, in Papua New Guinea, Workshop proceedings were published as a 2-volume series entitled 'Papua New Guinea Conservation Needs Assessment'.

Time frame
The CNA process for Papua New Guinea took 15 months from start to the completion of the Workshop and preparation of the Final Workshop map.

Examples of implementation
To date only one CNA has been implemented, in Papua New Guinea.

Points for and against
For
- CNAs adopt a truly multi-disciplinary approach to the conservation of biodiversity, focusing on both the social dimensions of conservation and the geographic dimensions of biodiversity.
- A CNA involves cooperation between the State, government and customary Landowners.
- The PNG CNA developed a process for information sharing and consensus-decision making.
- The PNG CNA covered both terrestrial and marine areas.

Against
- Requires the availability of substantial data sets (particularly GIS data layers).
- A CNA is really only the first stage in the setting of national or regional biodiversity conservation priorities. It identifies areas in which field surveys/conservation measures may be necessary. Their implementation is an entirely separate process.

Appraisal
CNAs effectively summarise the existing biological knowledge of a region or country, but in addition provide an overview of the social and economic factors affecting biodiversity, and take these into account when setting conservation priorities. They are most appropriate for setting conservation priorities in large, relatively unknown areas. As is the case with Conservation Biodiversity Workshops a CNA will also highlight areas where further field surveys are needed.

NATIONAL CONSERVATION REVIEW (using Gradsect sampling): Sri Lanka Forest Department

Source: Green, M.J.B. and Gunawardena, E.R.N. 1993.

Brief summary of technique
The aim of the National Conservation Review (NCR) is to identify an optimal or minimum set of sites which is representative of national biodiversity. This is achieved through the collection of data on species distributions and their subsequent analysis. Surveys are conducted to assess these distributions (see below). The sampling procedure involves the following steps:

1. Identification of sites
2. Positioning of transects along environmental gradients

3 Inventorying of flora and fauna within plots

The NCR also has a hydrological and soil conservation component. These attributes of forest are measured concurrently by a separate survey team. An iterative complementarity procedure is being used to define a minimum set of sites necessary to conserve Sri Lanka's biodiversity. This procedure is fully explained in Green and Gunawardena (1993).

In Sri Lanka, the survey technique employed was Gradient-directed transect (Gradsect) sampling. Transects are selected deliberately to traverse the steepest environmental gradients present in an area, while taking into account access routes. This technique is considered appropriate for rapidly assessing species diversity in natural forests, while minimising costs, since gradsects capture more biological information than randomly-placed transects of similar length. Altitude may be the most significant environment gradient, and was the one chosen in Sri Lanka. Others could be eg. precipitation, temperature, latitude etc.

Data needed

1 Sites for survey were identified based on a 1:500,000 forest map of Sri Lanka. An accurate topographic map is needed to locate the gradsects within the chosen site.

2 The presence or absence of species in selected groups of fauna and flora was ascertained during the field survey. Faunal groups inventoried were mammals, birds, reptiles, amphibians, butterflies, molluscs, and mound-building termites, while fishes were identified opportunistically. Floral inventory was restricted to woody plants.

Assessment of likely availability of data

Topographic maps are usually available for most countries. In extensive forests, Landsat TM images can be used to distinguish between different types of community, in order to ensure that each was representatively sampled.

Costs involved

The Gradsect survey technique is a field-oriented process. It involves low technological input, and costs are therefore likely to be low.

Human resources involved/required

A competent zoologist and botanist are required, together with unskilled labour to assist in positioning and marking the transects.

Data generated

The faunal part of the survey was restricted to identification of the presence of higher vertebrates and a few invertebrate groups (butterflies, molluscs, and mound-building termites). Floral survey was confined to woody species. Specimens were collected of species which could not be identified in the field, and were sent to museums for positive identification. Species lists were therefore generated for each forest surveyed. Subsequent analyses were based mainly on the woody plants data, because of the large number of biases involved in faunal survey, and the likelihood that faunal diversity was greatly under-estimated due to the speed at which the survey had to be conducted.

Time frame

The forests of the Southern Province of Sri Lanka, comprising 10% of the country, were surveyed in 1 year. To complete for the whole country would take an estimated further 4 years.

Examples of implementation

This technique has been carried out in Sri Lanka's forests under a UNDP/FAO/IUCN programme.

Points for and against

For

- An NCR using Gradsect sampling is based on real data, not hypothetical or modelled data.

- Gradsect sampling is relatively cheap.

Against

- As employed in Sri Lanka, the method is only suitable for investigating pre-identified sites, not selecting possible sites.
- The technique records the presence or absence of a species, but gives no indication of how abundant it is.
- The time-frame is long, but could be speeded up by training and deploying more survey teams.
- Identification of specimens by museums takes time and adds an element of delay.

Appraisal

This technique is suitable for the investigation of, and conservation priority setting between, pre-identified sites, but not for conducting a first-tranche assessment of biodiversity. Although it has only been used in forests, modifications to the methodology would enable its adaptation to other habitats as well. It would be suitable for small countries with a limited number of sites of conservation interest.

BIMS (BIODIVERSITY INFORMATION MANAGEMENT SYSTEM): Asian Bureau for Conservation

Source: MacKinnon, J. *pers comm.*

Brief summary of technique

The Asian Bureau for Conservation has developed and distributed a software package called BIMS (formerly MASS) which can be used for monitoring the conservation status of species, wildlife habitat and protected areas on a national basis. The underlying principle is that the distribution and occurrence of species whose habitat requirements are known is predictable: in other words a good naturalist with knowledge of the condition of a certain site can usually predict whether a particular species will be found there. BIMS monitors the status of individual species by assessing the extensiveness, rate of loss and degree of protection afforded to their required habitats.

The technique uses empirical modelling to estimate distribution and abundance patterns of species from sparse primary data, stored in a relational database. It includes estimates of the threats to the species being modelled. BIMS is based on a mapped habitat classification which uses a small fraction of the computer space that an equivalent approach to species mapping using GIS would.

Data needed

BIMS requires a mapped habitat classification (ie. the best available vegetation map) with the following minimal layers:

- physical base map
- biogeographical divisions
- habitat classification (original distribution)
- habitat classification (current distribution based on remote sensing)
- protected areas system

Topographic coverage, and knowledge of species habitat requirements (particularly habitat type and altitudinal range) are also required. Data on threats such as hunting can be added optionally to increase the accuracy of computer-generated predictions.

Assessment of likely availability of data

All countries are likely to have habitat classifications or vegetation maps available at some degree of resolution.

Costs involved

Relatively low.

Human resources involved/required
Competent computer operators and experienced biologists/naturalists are needed to input realistic data and model it correctly.

Data generated
BIMS can be used to generate predictive maps of species distribution, estimate population sizes, and assign categories of threat on a national basis.

Time frame
Can be very quick where data are available.

Examples of implementation
BIMS databases have been established in most Asian countries and have been used to determine conservation priorities in China, Thailand, Bhutan, Vietnam and Indonesia: for example in the preparation of a forestry masterplan for Bhutan (MacKinnon 1991).

Points for and against
For
- Provides 'maps' of species occurrence without using GIS technology
- Fast
- Cheap
- Gives acceptably accurate predictions of species actual occurrence
- Can be used to estimate species population sizes
- Can be used to assign categories of threat to individual species on a national basis

Against
- Not suitable for species whose habitat requirements are not well known
- Has so far only been used in Asia

Appraisal
Suitable as a first-cut approach to examining the biodiversity of a country and selecting species/habitats that are predicted to be threatened. Enables biodiversity managers to make sensible decisions about the relative value for biodiversity conservation of different areas, even in the absence of survey data. Predictions need to be validated by field survey before conservation measures were enacted on the ground.

GUIDELINES FOR THE RAPID ASSESSMENT OF BIODIVERSITY PRIORITY AREAS (RAP): CSIRO (and others)

Brief summary of technique
The World Bank and the GEF are currently funding CSIRO and other Australian institutions to develop a series of Guidelines for Rapid Assessment of Biodiversity Priority Areas (RAP). These will adapt RAP tools employed in Australia for use in developing countries. The basic principle is that priorities need to be set. The technique used will be to compile a suitable database containing maps of the spatial distribution of the biodiversity surrogate chosen, and then use it systematically to identify a network of areas that collectively represents that surrogate. A complementarity approach will be recommended, in which priority areas are added on the basis of the elements of biodiversity they contain which are different from those already covered.

Application of CSIRO guidelines will enable assessment of the relative contribution of different areas to overall biodiversity protection. Conservation initiatives will then focus on areas that make a high contribution.

Data needed
Some combination of data on the distributions of species, habitat types and environments are needed.

Assessment of likely availability of data
Which data are chosen will depend heavily on the actual availability of data.

Costs involved
Unknown, but expected to be low.

Human resources involved/required
Unknown, but it is expected that the Guidelines will recommend training of biodiversity technicians or 'para-taxonomists' to assist with field surveys.

Data generated
First phase products will include DOS-compatible databases for collating information from field surveys and collections, mapping tools for identifying areas of conservation concern, guidelines, and a handbook for their application.

Time frame
Unknown, but expected to be short.

Examples of implementation
The CSIRO Guidelines have not yet been fully developed or implemented.

Points for and against
For
- Will provide a manual for biodiversity managers interested in national biodiversity inventory
- Will provide DOS-compatible databases for collating information
- Scientists from developing countries will review the preparation and development of the CSIRO materials, ensuring that they are compatible with their aims

Against
- Methodology not yet available

Appraisal
The CSIRO guidelines will provide valuable overall approach to conducting baseline biodiversity inventories on a national basis. It is expected that they will consist of an amalgam of the most appropriate techniques discussed in this paper.

ALL TAXA BIODIVERSITY INVENTORY (ATBI) - University of Pennsylvania in conjunction with INBio, Costa Rica.

Source: Janzen, D.H. and Hallwachs, W. 1994.

Brief summary of technique
The aim of an All Taxa Biodiversity Inventory is to make a thorough inventory or description of all the species present in a particular area, using highly trained taxonomic specialists recruited internationally and nationally. The rationale behind this approach is that species have to be used (ie. must have a utilitarian value to human societies) in order to be preserved, and have to be described and understood before appropriate uses can be found for them.

Data needed
An All Taxa Biodiversity Inventory attempts to determine for all the taxa and a very large number of species in one area:
- What they are - ie. recognise and describe species and assign stable scientific binomial names. The latter facilitates information exchange about particular species between researchers working in different languages in different parts of the world.

- Where they are - determine where at least some of the members of each taxon or species live and can be found.
- What they do - through accumulation of ecological and behaviourial information, determine their role in the ecosystem.

Assessment of likely availability of data
It is extremely unlikely that data are currently available anywhere in the world at the level of detail required for an ATBI. However, specialists who could generate the required data do exist internationally for many taxonomic groups.

Costs involved
Hugely expensive. The proposed budget for a five-year programme in Guanacaste, Costa Rica, is US$ 88 million.

Human resources involved/required
The ATBI proposal for Guanacaste calls for 279 staff annually, including 100 'parataxonomists', trained locally by up to 40 visiting specialists.

Data generated
An enormous amount of basic data would potentially be generated.

Time frame
A thorough species-level inventory of a large and biodiverse area is impossible in less than 2-3 years. Two years of planning followed by five years of field activity is a more realistic estimate, and is the time scale proposed for the Guanacaste project.

Examples of implementation
To date, the ATBI approach has only been tried in the Guanacaste Conservation Area, a reserve of 110,000 ha containing three tropical forest ecosystems (dry forest, cloud forest and rain forest) in north-west Costa Rica.

Points for and against
For
- Produces a thorough inventory of a particular site, which could potentially be used as a benchmark from which other site evaluation techniques could be calibrated.
- Mutualistic scientific advantages from having scientists representing all the major taxa conduct their biodiversity actions at one site.
- High levels of training are associated with an ATBI: large numbers of graduate students and trained parataxonomists would be produced, most of them host nationals.

Against
- An ATBI attempts to inventory all taxa from viruses to trees and large mammals, which is very time-consuming.
- ATBI is an experimental technique, started in 1993 and representative results are not available.
- An ATBI is not an exercise in site choice for conservation planning, since it does not entail a comparison between sites.
- An ATBI is not directly applicable to marine environments.
- The technique involves a considerable input of specialist knowledge from invited expatriate systematists.

Appraisal
ATBI is not the right technique to apply to a number of sites to determine their conservation value. It is site-specific, expensive, and time-consuming. It relies totally on formal taxonomic identification of species - in complete contrast to Rapid Biodiversity Assessment (see below).

RAPID BIODIVERSITY ASSESSMENT (RBA): MacQuarie University

Source: Beattie, A. J., *et al.*, 1993.

Brief summary of technique
Rapid Biodiversity Assessment (RBA) is based on the premise that certain aspects of biological diversity can be quantified without knowing the scientific names of the species involved. The main characteristic of RBA is the minimisation of the formal taxonomic content in the classification and identification of organisms. There are two methods by which this can be achieved:

1. 'Ordinal' RBA. In this approach only those taxonomic levels needed to achieve the goals of the assessment in question are used. Ordinal RBA is frequently used in environmental monitoring. For example, if it is known from prior studies that the presence or absence of a particular family or genus indicates disturbance or pollution, it may only be necessary to resolve the species collected at a site to the level of family or genus to ascertain environmental quality.

2. 'Basic RBA'. If large numbers of specimens are obtained from a particular area during a biodiversity inventory their identification may be problematic. There may be a shortage of taxonomists familiar with the groups in question, or perhaps none available at all in the country in which the inventory is being carried out. An alternative to formal and correct species identification by expert taxonomists is the creation of locally functional schemes for classification and identification. Specimens can be distinguished by easily observable morphological criteria. For example, butterflies might be distinguished on the basis of wing colour, pattern and size resulting in classifications such as 'Small, red with white spots.' The units of variety recorded by such a scheme may be called morphospecies, operational taxonomic units (OTUs) or recognisable taxonomic units (RTUs). Depending on whether operational procedures have been standardised and calibrated by conventional taxonomic measures, these units may or may not be less representative of natural biological variation than species *per se.* Biodiversity technicians trained by taxonomists are used to separate specimens into RTUs. Studies show that if properly trained such personnel can be very effective.

Data needed
Data are gathered on certain groups of organisms. Several groups, chosen as good 'predictor sets' of biodiversity are needed at each location inventoried. Appropriate groups are ones which:
- Are relatively abundant
- Have a high species richness
- Contain many specialist species
- Are easy to sample
- Have taxonomic traits accessible to RBA methods

In contrast to RAPs (see below) which tend to use vertebrate and higher plant taxa as indicator groups, RBAs focus on invertebrate groups, such as butterflies, ants, termites, certain beetle families, grasshoppers and spiders.

Assessment of likely availability of data
Once the indicator groups of species have been chosen, RBA needs no further data.

Costs involved
Since the RBA technique utilises low-levels of technology and expertise, it is relatively cheap.

Human resources involved/required
Trained - but relatively unskilled - biodiversity technicians are needed to separate the organisms inventoried into recognisable taxonomic units. Identification to species level requires specialist taxonomists.

Data generated
Data obtained are representative measures of the species diversity of the area for particular taxonomic groups.

Time frame
RBAs are relatively quick.

Examples of implementation
RBA has been used extensively in recent years in Australia, where invertebrate groups (particularly ants) are increasingly used in environmental audit programmes. For example, Cranston and Hillman (1992) conducted RBAs at Ryan's Billabong and Mitta Mitta Creek in Australia using Odonata (dragonflies) Ephemeroptera (mayflies) and Chironomidae (midges) as indicator groups.

Points for and against
For
- Quick and cheap.
- Requires a low input of highly-skilled labour.
- Uses non-invasive sampling, eliminating the time spent in collecting specimens and subsequent identification.

Against
- Data are only directly comparable with other sites assessed by precisely the same method. Since no standard method exists, comparing data from neighbouring countries or between RBA programmes conducted by different organisations may prove difficult.
- RBAs focus on invertebrate groups. The relationships between biodiversity in different groups of invertebrates (and those with vertebrate diversity) are even less well understood than that between different groups of vertebrates and higher plants.

Appraisal
A very rapid, cheap and attractive way of assessing the relative biodiversity value of different sites: provided they are assessed using the same indicator groups of species. A type of national or regional overview is however required as a preliminary step to identify areas meriting investigation by RBA.

RAPID ASSESSMENT PROGRAMME (RAP): Conservation International

Source: Parker, T.A.P. III. *et al.*, 1993.

Brief summary of technique
Conservation International (CI) created the Rapid Assessment Program (RAP) in 1989 to fill the gaps in regional knowledge of the world's biodiversity 'hotspots'. These hotspots cover less than 4% of the Earth's surface, but remain inadequately inventoried.

The RAP process assembles teams of international experts and host country scientists to conduct preliminary assessments of the biological value of poorly-known areas. RAP teams usually consist of experts in taxonomically well-known groups such as higher vertebrates (eg. birds and mammals) and vascular plants, so that ready identification of organisms to the species level is possible. The biological value of an area can be characterised by species richness, degree of species endemism (ie. percentage of species that are found nowhere else), the uniqueness of the ecosystem, and the magnitude of threat of extinction. A RAP is a precursor to prolonged scientific study.

RAPs are undertaken by identifying potentially rich sites from satellite images/aerial reconnaissance, and then sending in ground teams to conduct field survey transects. Such field trips last from two to eight weeks, depending on the remoteness of the terrain. Reports of RAP activities are made available to the widest possible audience. Subsequent research and conservation recommendations and actions are the responsibility of local scientists and conservationists.

Data needed

1 Satellite images are used where available, to determine the extent of forest cover and likely areas which would repay investigation.

2 Aerial reconnaissance data are needed from surveys in small aircraft or helicopters to identify vegetation types and points for field transects.

3 Field survey transects, undertaken on foot, by car or boat. Species groups inventoried are usually vascular plants and higher vertebrates (mammals, birds, reptiles and amphibians).

Assessment of likely availability of data

By definition RAPs are conducted in relatively unknown regions, where previous scientific studies are rare. At a minimum, survey overflights and field transects are needed to conduct a RAP.

Costs involved

No indication of the costs involved is currently available.

Human resources involved/required

Local experts are a central part of any RAP team, especially critical to understanding areas where little exploration has been undertaken. However, one of the key elements is the participation of international experts, who are able to review the results obtained from a global or regional perspective.

Data generated

Preliminary species lists for the groups inventoried: vascular plants and higher vertebrates.

Time frame

Rapid Assessment is by its nature a very quick, first-cut, attempt at inventorying the biodiversity of a region. CI conducted the fieldwork for one RAP of an area of 50,000 km^2 of forested eastern Andean slopes in Alto Madidi, north west Bolivia, in one month (Parker and Bailey 1990). It should be noted that field transects were restricted to small areas within this.

Examples of implementation

CI has carried out RAPs in various forested parts of South America. So far the lowland and montane forests of Alto Madidi, in La Paz state, and the dry lowland forests of Santa Cruz (Bolivia); the Cordillera de la Costa (Ecuador); the Columbia River Forest Reserve (Belize); and the Kanuku Mountain region (Guyana) have been inventoried by RAP.

Points for and against

For

- Quick: RAPs to date have taken around 1 month of fieldwork.
- Uses non-invasive sampling, eliminating the time spent in collecting specimens and subsequent identification.
- Data gathered are fully comparable with those collected from other areas.
- Produces preliminary species inventories for major taxa, filling in gaps in scientific knowledge.

Against

- In large areas, focuses (through necessity) on small local sample sites.
- Compared to RBA needs a higher level of technical input from experts.

Appraisal

RAPs are most suited for investigating the biological diversity of previously unexplored areas. in a comparison between relatively known sites, RBAs are probably cheaper and quicker.

Similar ... are used when ... to determine the ... of ... which ... investigations.

Field surveys, undertaken ... vascular plants and higher vertebrates ...

... of likely availability of data

By definition LAPs are conducted ... a minimum, survey ... and then ...

Costs involved

Identification of the ... involved is generally ...

... reports are a critical part of ...

... checklists for the groups ... vascular plants and higher ...

... assessment ... by its ...

Implementation

... of RAPs in various forested parts of South America ...

ANNEX 3

IUCN RED LIST CATEGORIES

Prepared by the

IUCN Species Survival Commission

As approved by the
40th Meeting of the IUCN Council
Gland, Switzerland

30 November 1994

IUCN RED LIST CATEGORIES

I) Introduction

1. The threatened species categories now used in Red Data Books and Red Lists have been in place, with some modification, for almost 30 years. Since their introduction these categories have become widely recognised internationally, and they are now used in a whole range of publications and listings, produced by IUCN as well as by numerous governmental and non-governmental organisations. The Red Data Book categories provide an easily and widely understood method for highlighting those species under higher extinction risk, so as to focus attention on conservation measures designed to protect them.

2. The need to revise the categories has been recognised for some time. In 1984, the SSC held a symposium, 'The Road to Extinction' (Fitter & Fitter 1987), which examined the issues in some detail, and at which a number of options were considered for the revised system. However, no single proposal resulted. The current phase of development began in 1989 with a request from the SSC Steering Committee to develop a new approach that would provide the conservation community with useful information for action planning.

In this document, proposals for new definitions for Red List categories are presented. The general aim of the new system is to provide an explicit, objective framework for the classification of species according to their extinction risk.

The revision has several specific aims:

- to provide a system that can be applied consistently by different people;
- to improve the objectivity by providing those using the criteria with clear guidance on how to evaluate different factors which affect risk of extinction;
- to provide a system which will facilitate comparisons across widely different taxa;
- to give people using threatened species lists a better understanding of how individual species were classified.

3. The proposals presented in this document result from a continuing process of drafting, consultation and validation. It was clear that the production of a large number of draft proposals led to some confusion, especially as each draft has been used for classifying some set of species for conservation purposes. To clarify matters, and to open the way for modifications as and when they became necessary, a system for version numbering was applied as follows:

Version 1.0: Mace & Lande (1991)
The first paper discussing a new basis for the categories, and presenting numerical criteria especially relevant for large vertebrates.

Version 2.0: Mace *et al.* (1992)
A major revision of Version 1.0, including numerical criteria appropriate to all organisms and introducing the non-threatened categories.

Version 2.1: IUCN (1993)

Following an extensive consultation process within SSC, a number of changes were made to the details of the criteria, and fuller explanation of basic principles was included. A more explicit structure clarified the significance of the non-threatened categories.

Version 2.2: Mace & Stuart (1994)

Following further comments received and additional validation exercises, some minor changes to the criteria were made. In addition, the Susceptible category present in Versions 2.0 and 2.1 was subsumed into the Vulnerable category. A precautionary application of the system was emphasised.

Final Version

This final document, which incorporates changes as a result of comments from IUCN members, was adopted by the IUCN Council in December 1994.

All future taxon lists including categorisations should be based on this version, and not the previous ones.

4. In the rest of this document the proposed system is outlined in several sections. The Preamble presents some basic information about the context and structure of the proposal, and the procedures that are to be followed in applying the definitions to species. This is followed by a section giving definitions of terms used. Finally the definitions are presented, followed by the quantitative criteria used for classification within the threatened categories. It is important for the effective functioning of the new system that all sections are read and understood, and the guidelines followed.

References:

Fitter, R., and M. Fitter, ed. (1987) *The Road to Extinction.* Gland, Switzerland: IUCN.

IUCN. (1993) *Draft IUCN Red List Categories.* Gland, Switzerland: IUCN.

Mace, G. M. *et al.* (1992) "The development of new criteria for listing species on the IUCN Red List." *Species* 19: 16-22.

Mace, G. M., and R. Lande. (1991) "Assessing extinction threats: toward a reevaluation of IUCN threatened species categories." *Conserv. Biol.* 5.2: 148-157.

Mace, G. M. & S. N. Stuart. (1994) "Draft IUCN Red List Categories, Version 2.2". *Species* 21-22: 13-24.

II) Preamble

The following points present important information on the use and interpretation of the categories (= Critically Endangered, Endangered, etc.), criteria (= A to E), and sub-criteria (= a,b etc., i,ii etc.):

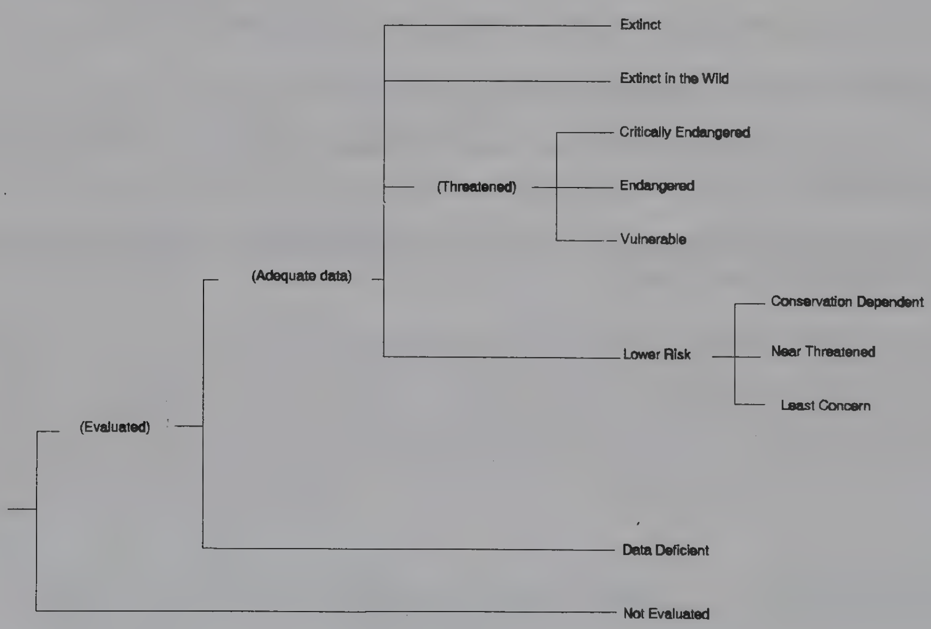
1. Taxonomic level and scope of the categorisation process

The criteria can be applied to any taxonomic unit at or below the species level. The term 'taxon' in the following notes, definitions and criteria is used for convenience, and may represent species or lower taxonomic levels, including forms that are not yet formally described. There is a sufficient range among the different criteria to enable the appropriate listing of taxa from the complete taxonomic spectrum, with the exception of micro-organisms. The criteria may also be applied within any specified geographical or political area although in such cases special notice should be taken of point 11 below. In presenting the results of applying the criteria, the taxonomic unit and area under consideration should be made explicit. The categorisation process should only be applied to wild populations inside their natural range, and to populations resulting from benign introductions (defined in the draft IUCN Guidelines for Re-introductions as "..an attempt to establish a species, for the purpose of conservation, outside its recorded distribution, but within an appropriate habitat and eco-geographical area").

2. Nature of the categories

All taxa listed as Critically Endangered qualify for Vulnerable and Endangered, and all listed as Endangered qualify for Vulnerable. Together these categories are described as 'threatened'. The threatened species categories form a part of the overall scheme. It will be possible to place all taxa into one of the categories (see Figure 1).

Figure 1: Structure of the Categories



3. **Role of the different criteria**

For listing as Critically Endangered, Endangered or Vulnerable there is a range of quantitative criteria; meeting any one of these criteria qualifies a taxon for listing at that level of threat. Each species should be evaluated against all the criteria. The different criteria (A-E) are derived from a wide review aimed at detecting risk factors across the broad range of organisms and the diverse life histories they exhibit. Even though some criteria will be inappropriate for certain taxa(some taxa will never qualify under these however close to extinction they come), there should be criteria appropriate for assessing threat levels for any taxon (other than micro-organisms). The relevant factor is whether any one criterion is met, not whether all are appropriate or all are met. Because it will never be clear which criteria are appropriate for a particular species in advance, each species should be evaluated against all the criteria, and any criterion met should be listed.

4. **Derivation of quantitative criteria**

The quantitative values presented in the various criteria associated with threatened categories were developed through wide consultation and they are set at what are generally judged to be appropriate levels, even if no formal justification for these values exists. The levels for different criteria within categories were set independently but against a common standard. Some broad consistency between them was sought. However, a given taxon should not be expected to meet all criteria (A-E) in a category; meeting any one criterion is sufficient for listing.

5. **Implications of listing**

Listing in the categories of Not Evaluated and Data Deficient indicates that no assessment of extinction risk has been made, though for different reasons. Until such time as an assessment is made, species listed in these categories should not be treated as if they were non-threatened, and it may be appropriate (especially for Data Deficient forms) to give them the same degree of protection as threatened taxa, at least until their status can be evaluated.

Extinction is assumed here to be a chance process. Thus, a listing in a higher extinction risk category implies a higher expectation of extinction, and over the time-frames specified more taxa listed in a higher category are expected to go extinct than in a lower one (without effective conservation action). However, the persistence of some taxa in high risk categories does not necessarily mean their initial assessment was inaccurate.

6. **Data quality and the importance of inference and projection**

The criteria are clearly quantitative in nature. However, the absence of high quality data should not deter attempts at applying the criteria, as methods involving estimation, inference and projection are emphasised to be acceptable throughout. Inference and projection may be based on extrapolation of current or potential threats into the future (including their rate of change), or of factors related to population abundance or distribution (including dependence on other taxa), so long as these can reasonably be supported. Suspected or inferred patterns in either the recent past, present or near future can be based on any of a series of related factors, and these factors should be specified.

Taxa at risk from threats posed by future events of low probability but with severe consequences (catastrophes) should be identified by the criteria (e.g. small distributions, few locations). Some threats need to be identified particularly early, and appropriate actions taken, because their effects are irreversible, or nearly so (pathogens, invasive organisms, hybridization).

7. **Uncertainty**

The criteria should be applied on the basis of the available evidence on taxon numbers, trend and distribution, making due allowance for statistical and other uncertainties. Given that data are rarely available for the whole range or population of a taxon, it may often be appropriate to use the information that is available to make intelligent inferences about the overall status of the taxon in question. In cases where a wide variation in estimates is found, it is legitimate to apply the precautionary principle and use the estimate (providing it is credible) that leads to listing in the category of highest risk.

Where data are insufficient to assign a category (including Lower Risk), the category of 'Data Deficient' may be assigned. However, it is important to recognise that this category indicates that data are inadequate to determine the degree of threat faced by a taxon, not necessarily that the taxon is poorly known. In cases where there are evident threats to a taxon through, for example, deterioration of its only known habitat, it is important to attempt threatened listing, even though there may be little direct information on the biological status of the taxon itself. The category 'Data Deficient' is not a threatened category, although it indicates a need to obtain more information on a taxon to determine the appropriate listing.

8. **Conservation actions in the listing process**

The criteria for the threatened categories are to be applied to a taxon whatever the level of conservation action affecting it. In cases where it is only conservation action that prevents the taxon from meeting the threatened criteria, the designation of 'Conservation Dependent' is appropriate. It is important to emphasise here that a taxon require conservation action even if it is not listed as threatened.

9. **Documentation**

All taxon lists including categorisation resulting from these criteria should state the criteria and sub-criteria that were met. No listing can be accepted as valid unless at least one criterion is given. If more than one criterion or sub-criterion was met, then each should be listed. However, failure to mention a criterion should not necessarily imply that it was not met. Therefore, if a re-evaluation indicates that the documented criterion is no longer met, this should not result in automatic down-listing. Instead, the taxon should be re-evaluated with respect to all criteria to indicate its status. The factors responsible for triggering the criteria, especially where inference and projection are used, should at least be logged by the evaluator, even if they cannot be included in published lists.

10. **Threats and priorities**

The category of threat is not necessarily sufficient to determine priorities for conservation action. The category of threat simply provides an assessment of the likelihood of extinction under current circumstances, whereas a system for assessing priorities for action will include numerous other factors concerning conservation action such as costs, logistics, chances of success, and even perhaps the taxonomic distinctiveness of the subject.

11. **Use at regional level**

The criteria are most appropriately applied to whole taxa at a global scale, rather than to those units defined by regional or national boundaries. Regionally or nationally based threat categories, which are aimed at including taxa that are threatened at regional or national levels (but not necessarily throughout their global ranges), are best used with two key pieces of information: the global status category for the taxon, and the proportion of the global population or range that occurs within the region or nation. However, if applied at regional or national level it must be recognised that a global category of threat may not be the same as a regional or national category for a particular taxon. For example, taxa classified as Vulnerable on the basis of their global declines in numbers or range might be Lower Risk within a particular region where their populations are stable. Conversely, taxa classified as Lower Risk globally might be Critically Endangered within a particular region where numbers are very small or declining, perhaps only because they are at the margins of their global range. IUCN is still in the process of developing guidelines for the use of national red list categories.

12. **Re-evaluation**

Evaluation of taxa against the criteria should be carried out at appropriate intervals. This is especially important for taxa listed under Near Threatened, or Conservation Dependent, and for threatened species whose status is known or suspected to be deteriorating.

13. **Transfer between categories**

There are rules to govern the movement of taxa between categories. These are as follows: (A) A taxon may be moved from a category of higher threat to a category of lower threat if none of the criteria of the higher category has been met for 5 years or more. (B) If the original classification is found to have been erroneous,

the taxon may be transferred to the appropriate category or removed from the threatened categories altogether, without delay (but see Section 9). (C) Transfer from categories of lower to higher risk should be made without delay.

14. **Problems of scale**
Classification based on the sizes of geographic ranges or the patterns of habitat occupancy is complicated by problems of spatial scale. The finer the scale at which the distributions or habitats of taxa are mapped, the smaller will be the area that they are found to occupy. Mapping at finer scales reveals more areas in which the taxon is unrecorded. It is impossible to provide any strict but general rules for mapping taxa or habitats; the most appropriate scale will depend on the taxa in question, and the origin and comprehensiveness of the distributional data. However, the thresholds for some criteria (e.g. Critically Endangered) necessitate mapping at a fine scale.

III) Definitions

1. **Population**
Population is defined as the total number of individuals of the taxon. For functional reasons, primarily owing to differences between life-forms, population numbers are expressed as numbers of mature individuals only. In the case of taxa obligately dependent on other taxa for all or part of their life cycles, biologically appropriate values for the host taxon should be used.

2. **Subpopulations**
Subpopulations are defined as geographically or otherwise distinct groups in the population between which there is little exchange (typically one successful migrant individual or gamete per year or less).

3. **Mature individuals**
The number of mature individuals is defined as the number of individuals known, estimated or inferred to be capable of reproduction. When estimating this quantity the following points should be borne in mind:

- Where the population is characterised by natural fluctuations the minimum number should be used.

- This measure is intended to count individuals capable of reproduction and should therefore exclude individuals that are environmentally, behaviourally or otherwise reproductively suppressed in the wild.

- In the case of populations with biased adult or breeding sex ratios it is appropriate to use lower estimates for the number of mature individuals which take this into account (e.g. the estimated effective population size).

- Reproducing units within a clone should be counted as individuals, except where such units are unable to survive alone (e.g. corals).

- In the case of taxa that naturally lose all or a subset of mature individuals at some point in their life cycle, the estimate should be made at the appropriate time, when mature individuals are available for breeding.

4. **Generation**
Generation may be measured as the average age of parents in the population. This is greater than the age at first breeding, except in taxa where individuals breed only once.

5. Continuing decline

A continuing decline is a recent, current or projected future decline whose causes are not known or not adequately controlled and so is liable to continue unless remedial measures are taken. Natural fluctuations will not normally count as a continuing decline, but an observed decline should not be considered to be part of a natural fluctuation unless there is evidence for this.

6. Reduction

A reduction (criterion A) is a decline in the number of mature individuals of at least the amount (%) stated over the time period (years) specified, although the decline need not still be continuing. A reduction should not be interpreted as part of a natural fluctuation unless there is good evidence for this. Downward trends that are part of natural fluctuations will not normally count as a reduction.

7. Extreme fluctuations

Extreme fluctuations occur in a number of taxa where population size or distribution area varies widely, rapidly and frequently, typically with a variation greater than one order of magnitude (i.e., a tenfold increase or decrease).

8. Severely fragmented

Severely fragmented is refers to the situation where increased extinction risks to the taxon result from the fact that most individuals within a taxon are found in small and relatively isolated subpopulations. These small subpopulations may go extinct, with a reduced probability of recolonisation.

9. Extent of occurrence

Extent of occurrence is defined as the area contained within the shortest continuous imaginary boundary which can be drawn to encompass all the known, inferred or projected sites of present occurrence of a taxon, excluding cases of vagrancy. This measure may exclude discontinuities or disjunctions within the overall distributions of taxa (e.g., large areas of obviously unsuitable habitat) (but see 'area of occupancy'). Extent of occurrence can often be measured by a minimum convex polygon (the smallest polygon in which no internal angle exceeds 180 degrees and which contains all the sites of occurrence).

10. Area of occupancy

Area of occupancy is defined as the area within its 'extent of occurrence' (see definition) which is occupied by a taxon, excluding cases of vagrancy. The measure reflects the fact that a taxon will not usually occur throughout the area of its extent of occurrence, which may, for example, contain unsuitable habitats. The area of occupancy is the smallest area essential at any stage to the survival of existing populations of a taxon (e.g. colonial nesting sites, feeding sites for migratory taxa). The size of the area of occupancy will be a function of the scale at which it is measured, and should be at a scale appropriate to relevant biological aspects of the taxon. The criteria include values in km^2, and thus to avoid errors in classification, the area of occupancy should be measured on grid squares (or equivalents) which are sufficiently small (see Figure 2).

11. Location

Location defines a geographically or ecologically distinct area in which a single event (e.g. pollution) will soon affect all individuals of the taxon present. A location usually, but not always, contains all or part of a subpopulation of the taxon, and is typically a small proportion of the taxon's total distribution.

12. Quantitative analysis

A quantitative analysis is defined here as the technique of population viability analysis (PVA), or any other quantitative form of analysis, which estimates the extinction probability of a taxon or population based on the known life history and specified management or non-management options. In presenting the results of quantitative analyses the structural equations and the data should be explicit.

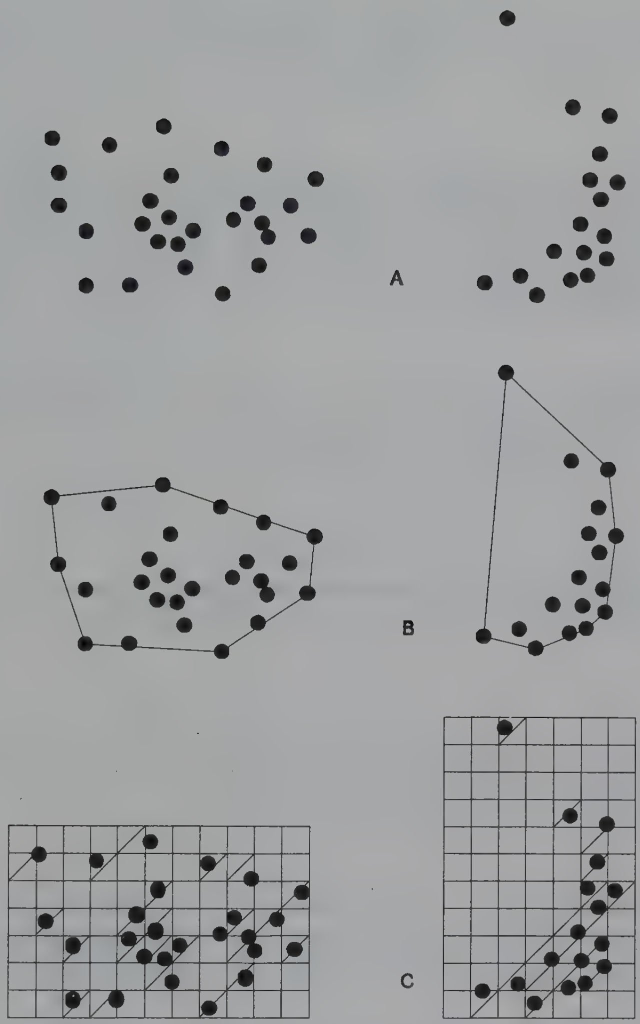


Figure 2:

Two examples of the distinction between extent of occurrence and area of occupancy. (a) is the spatial distribution of known, inferred or projected sites of occurrence. (b) shows one possible boundary to the extent of occurrence, which is the measured area within this boundary. (c) shows one measure of area of occupancy which can be measured by the sum of the occupied grid squares.

IV) The categories [1]

EXTINCT (EX)
A taxon is Extinct when there is no reasonable doubt that the last individual has died.

EXTINCT IN THE WILD (EW)
A taxon is Extinct in the wild when it is known only to survive in cultivation, in captivity or as a naturalised population (or populations) well outside the past range. A taxon is presumed extinct in the wild when exhaustive surveys in known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual. Surveys should be over a time frame appropriate to the taxon's life cycle and life form.

CRITICALLY ENDANGERED (CR)
A taxon is Critically Endangered when it is facing an extremely high risk of extinction in the wild in the immediate future, as defined by any of the criteria (A to E) on pages 12 and 13.

ENDANGERED (EN)
A taxon is Endangered when it is not Critically Endangered but is facing a very high risk of extinction in the wild in the near future, as defined by any of the criteria (A to E) on pages 14 and 15.

VULNERABLE (VU)
A taxon is Vulnerable when it is not Critically Endangered or Endangered but is facing a high risk of extinction in the wild in the medium-term future, as defined by any of the criteria (A to D) on pages 16 and 17.

LOWER RISK (LR)
A taxon is Lower Risk when it has been evaluated, does not satisfy the criteria for any of the categories Critically Endangered, Endangered or Vulnerable. Taxa included in the Lower Risk category can be separated into three subcategories:

1. **Conservation Dependent (cd).** Taxa which are the focus of a continuing taxon-specific or habitat-specific conservation programme targeted towards the taxon in question, the cessation of which would result in the taxon qualifying for one of the threatened categories above within a period of five years.

2. **Near Threatened (nt).** Taxa which do not qualify for Conservation Dependent, but which are close to qualifying for Vulnerable.

3. **Least Concern (lc).** Taxa which do not qualify for Conservation Dependent or Near Threatened.

DATA DEFICIENT (DD)
A taxon is Data Deficient when there is inadequate information to make a direct, or indirect, assessment of its risk of extinction based on its distribution and/or population status. A taxon in this category may be well

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[1] Note: As in previous IUCN categories, the abbreviation of each category (in parenthesis) follows the English denominations when translated into other languages.

studied, and its biology well known, but appropriate data on abundance and/or distribution is lacking. Data Deficient is therefore not a category of threat or Lower Risk. Listing of taxa in this category indicates that more information is required and acknowledges the possibility that future research will show that threatened classification is appropriate. It is important to make positive use of whatever data are available. In many cases great care should be exercised in choosing between DD and threatened status. If the range of a taxon is suspected to be relatively circumscribed, if a considerable period of time has elapsed since the last record of the taxon, threatened status may well be justified.

NOT EVALUATED (NE)
A taxon is Not Evaluated when it is has not yet been assessed against the criteria.

V) The Criteria for Critically Endangered, Endangered and Vulnerable

CRITICALLY ENDANGERED (CR)

A taxon is Critically Endangered when it is facing an extremely high risk of extinction in the wild in the immediate future, as defined by any of the following criteria (A to E):

A) Population reduction in the form of either of the following:

1) An observed, estimated, inferred or suspected reduction of at least 80% over the last 10 years or three generations, whichever is the longer, based on (and specifying) any of the following:

   a) direct observation
   b) an index of abundance appropriate for the taxon
   c) a decline in area of occupancy, extent of occurrence and/or quality of habitat
   d) actual or potential levels of exploitation
   e) the effects of introduced taxa, hybridisation, pathogens, pollutants, competitors or parasites.

2) A reduction of at least 80%, projected or suspected to be met within the next ten years or three generations, whichever is the longer, based on (and specifying) any of (b), (c), (d) or (e) above.

B) Extent of occurrence estimated to be less than 100 km^2 or area of occupancy estimated to be less than 10 km^2, and estimates indicating any two of the following:

1) Severely fragmented or known to exist at only a single location.

2) Continuing decline, observed, inferred or projected, in any of the following:

   a) extent of occurrence
   b) area of occupancy
   c) area, extent and/or quality of habitat
   d) number of locations or subpopulations
   e) number of mature individuals.

3) Extreme fluctuations in any of the following:

   a) extent of occurrence
   b) area of occupancy
   c) number of locations or subpopulations

d) number of mature individuals.

C) Population estimated to number less than 250 mature individuals and either:

1) An estimated continuing decline of at least 25% within 3 years or one generation, whichever is longer or

2) A continuing decline, observed, projected, or inferred, in numbers of mature individuals and population structure in the form of either:

a) severely fragmented (i.e. no subpopulation estimated to contain more than 50 mature individuals)
b) all individuals are in a single subpopulation.

D) Population estimated to number less than 50 mature individuals.

E) Quantitative analysis showing the probability of extinction in the wild is at least 50% within 10 years or 3 generations, whichever is the longer.

ENDANGERED (EN)
A taxon is Endangered when it is not Critically Endangered but is facing a very high risk of extinction in the wild in the near future, as defined by any of the following criteria (A to E):

A) Population reduction in the form of either of the following:

1) An observed, estimated, inferred or suspected reduction of at least 50% over the last 10 years or three generations, whichever is the longer, based on (and specifying) any of the following:

a) direct observation
b) an index of abundance appropriate for the taxon
c) a decline in area of occupancy, extent of occurrence and/or quality of habitat
d) actual or potential levels of exploitation
e) the effects of introduced taxa, hybridisation, pathogens, pollutants, competitors or parasites.

2) A reduction of at least 50%, projected or suspected to be met within the next ten years or three generations, whichever is the longer, based on (and specifying) any of (b), (c), (d), or (e) above.

B) Extent of occurrence estimated to be less than 5000 km^2 or area of occupancy estimated to be less than 500 km^2, and estimates indicating any two of the following:

1) Severely fragmented or known to exist at no more than five locations.

2) Continuing decline, inferred, observed or projected, in any of the following:

a) extent of occurrence
b) area of occupancy
c) area, extent and/or quality of habitat
d) number of locations or subpopulations
e) number of mature individuals.

3) Extreme fluctuations in any of the following:

    a) extent of occurrence
    b) area of occupancy
    c) number of locations or subpopulations
    d) number of mature individuals.

C) Population estimated to number less than 2500 mature individuals and either:

1) An estimated continuing decline of at least 20% within 5 years or 2 generations, whichever is longer, or

2) A continuing decline, observed, projected, or inferred, in numbers of mature individuals and population structure in the form of either:

    a) severely fragmented (i.e. no subpopulation estimated to contain more than 250 mature individuals)
    b) all individuals are in a single subpopulation.

D) Population estimated to number less than 250 mature individuals.

E) Quantitative analysis showing the probability of extinction in the wild is at least 20% within 20 years or 5 generations, whichever is the longer.

VULNERABLE (VU)

A taxon is Vulnerable when it is not Critically Endangered or Endangered but is facing a high risk of extinction in the wild in the medium-term future, as defined by any of the following criteria (A to E):

A) Population reduction in the form of either of the following:

1) An observed, estimated, inferred or suspected reduction of at least 20% over the last 10 years or three generations, whichever is the longer,, based on (and specifying) any of the following:

    a) direct observation
    b) an index of abundance appropriate for the taxon
    c) a decline in area of occupancy, extent of occurrence and/or quality of habitat
    d) actual or potential levels of exploitation
    e) the effects of introduced taxa, hybridisation, pathogens, pollutants, competitors or parasites.

2) A reduction of at least 20%, projected or suspected to be met within the next ten years or three generations, whichever is the longer, based on (and specifying) any of (b), (c), (d) or (e) above.

B) Extent of occurrence estimated to be less than 20,000 km^2 or area of occupancy estimated to be less than 2000 km^2, and estimates indicating any two of the following:

1) Severely fragmented or known to exist at no more than ten locations.

2) Continuing decline, inferred, observed or projected, in any of the following:

   a) extent of occurrence
   b) area of occupancy
   c) area, extent and/or quality of habitat
   d) number of locations or subpopulations
   e) number of mature individuals.

3) Extreme fluctuations in any of the following:

   a) extent of occurrence
   b) area of occupancy
   c) number of locations or subpopulations
   d) number of mature individuals.

C) Population estimated to number less than 10,000 mature individuals and either:

   1) An estimated continuing decline of at least 10% within 10 years or 3 generations, whichever is longer, or

   2) A continuing decline, observed, projected, or inferred, in numbers of mature individuals and population structure in the form of either:

      a) severely fragmented (i.e. no subpopulation estimated to contain more than 1000 mature individuals)
      b) all individuals are in a single subpopulation.

D) Population very small or restricted in the form of either of the following:

   1) Population estimated to number less than 1000 mature individuals.

   2) Population is characterised by an acute restriction in its area of occupancy (typically less than 100 km^2) or in the number of locations (typically less than 5). Such a taxon would thus be prone to the effects of human activities (or stochastic events whose impact is increased by human activities) within a very short period of time in an unforeseeable future, and is thus capable of becoming Critically Endangered or even Extinct in a very short period.

E) Quantitative analysis showing the probability of extinction in the wild is at least 10% within 100 years.

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